

The BSS Sundial Glossary

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A sourcebook of dialling data



FOREWORD TO THE SECOND EDITION

(available only in printed form – see [Publications](#))

The first edition of the Glossary was well received but, naturally, many readers found omissions or inconsistencies in some of the entries. These have now hopefully been addressed, although a work like this will never be completed. The major areas added for this edition are a set of thumbnail biographies of the major players in the development of dialling, an expansion of the Equations section to include more dial types, and a major increase in the number of appendices providing solar and other data.

March 2004

PREFACE TO THE FIRST EDITION

Several letters to the BSS Bulletin in 1999 suggested that a sundialling glossary would be useful in furthering the Society's aims. It is hoped that this resulting glossary will fulfil two objectives. The first of these is to provide newcomers to dialling with a reference document which will explain the many strange terms or unusual usages of common words which they will come across in the dialling literature.

The second objective is to try to produce definitive meanings of the terms which diallists sometimes use rather loosely, and which can therefore lead to some confusion. Thus when several words have the same meaning, the preferred use is described here. Likewise, an attempt has been made to produce a standardised set of symbols for the most widely used terms in dialling equations.

Choices between different meanings have been made on the basis of adopting the most common modern usage found in the literature (particularly those items shown in the Sources section) as long as this does not produce confusion. Alternative usages, spellings or conventions which may be met, particularly in early dialling works, have been given where possible, but it is hoped that future authors will adopt the preferred definitions given here.

As English is used in countries other than the UK, there may be alternative definitions overseas. However, this glossary has been assembled with collaboration from the North American Sundial Society and, via the medium of the internet, diallists worldwide, so it is not expected that there will be major differences in terminology throughout the majority of the English-speaking world.

May 2000

SCOPE

The glossary contains mainly terms which are directly related to dials and dialling. Additionally, excursions into the fields of astronomy, horology, optics and solar sciences have been made where it seems useful. Some comments on the history of dialling are made and various solar data are given in the appendices.

NOTATION

Words in *italics* refer to entries in this glossary or other internal references.

Bold text indicates a definition.

~ indicates a repeat of the entry word.

Symbols in square brackets [**x**, **X**] give the preferred symbol and abbreviation. See section on **Symbols** for a full list.

Alternative spellings or terms to the preferred ones are shown in brackets thus: **{dialling}**.

Pronunciation of unusual words is shown with a simplified phonetic scheme thus: **gnomon**: (pron. no-mon). If no pronunciation is given for an entry, it is pronounced as it is written (following normal Oxford Dictionary rules for English pronunciation).

ACKNOWLEDGEMENTS

I would like to thank the numerous members of the BSS and the NASS who helped with the definitions of terms, and who provided encouragement to the project. These include, in no particular order, Margaret Stanier, David Young, Patrick Powers, John Carmichael, Harvey Frey, Tony Wood, John Ingram, Doug Bateman, Frank and Rosie Evans, David Scott, Robert Terwilliger, Fer de Vries, Fred Sawyer, Gianni Ferrari, Tony Baigent, Chris Lusby Taylor, Mac Oglesby, Vit Planocka, Daniel Wenger, Gordon Taylor, Michael Lowne, Sara Schechner, Robert van Gent, Tony Moss, Allan Mills, Thibaud Taudin-Chabot, Gerald Stancey, Mike Cowham, Gloria Clifton, Peter Ransom, George Huxley, Chris Daniel, Jill Wilson, Mike Shaw, Michael Harley, Paul Zoller, Tony Belk.

A note on the Southern Hemisphere.

This glossary has been written primarily for the Northern Hemisphere, since this is where the majority (but not all) of the BSS membership resides. For horizontal dials in the Southern Hemisphere the gnomons point to the S celestial pole, and the hour numbers run anti-clockwise rather than clockwise. The notation and equations used in the glossary are consistent as long as the sign conventions are followed, but the reader must mentally change N to S in the text.

PRINTED VERSION

The second edition of the Glossary is published by the British Sundial Society as a printed book which is now [available](#).

UPDATES TO THE EDITOR

It is proposed to update this glossary periodically, so that it will develop along with the science of dialling. If you have any comments, corrections or additions, please [email the editor](#) or write to the address below.

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A

aberration (of light): the effect by which the apparent direction of distant astronomical bodies is altered by the velocity of the Earth and the finite speed of light. Discovered by James Bradley, it has a value of 20.47 arc-sec and is thus totally insignificant to dialling.

accuracy (of a dial): a measure of how closely the time indicators (lines or points) of a dial indicate the true time. Contrast with [resolution](#). See also [precision](#).

Act of 1751: {1752} refers to an act of the British parliament in that year which finally adopted the [Gregorian calendar](#) and set the beginning of the (English) year to 1 January, rather than 25 March. As a result, there can be some confusion about the year, prior to 1752, for dates between January and March. Scotland's New Year's Day had already been set to 1 January since 1600. Dates in the Julian calendar are usually denoted "Old Style", with those in the Gregorian "New Style".

British dials made before 1752 and which have [EoT](#) or [sunrise/sunset](#) tables show dates 11 days earlier than the current ones, e.g. the [vernal equinox](#) is on 10 March instead of 21 March, and the EoT will be shown as zero on 5 April, 3 June, 23 August and 15 December. Note that the Act was passed in 1751 but did not come into operation until the following year, hence the alternative dates sometimes seen.

acute angle

An angle of less than 90°.

age of the moon

See [phase of the moon](#).

almanac

An annual calendar of months and days, with astronomical and other data. They usually include an [ephemeris](#) of the Sun and some other celestial bodies, the [equation of time](#), the [Sun's declination](#) etc. Almanacs are sometimes inscribed on, or accompany, C16-18 dials.

The annual Nautical Almanac, produced by the Royal Greenwich Observatory, derives from the version first published by Astronomer Royal Nevil Maskelyne in 1767.

almucantar

A circle of equal [altitude](#) on the [celestial sphere](#). It is a [small circle](#) on the celestial sphere, parallel to the [horizon](#).

alidade

The revolving arm of an astrolabe through which sightings of the stars are made. Sometimes used on sundials where a pinhole at one end of the ~ forms an image of the Sun on a plate at the other end carrying an [analemma](#).

altazimuth

A mounting system for an astronomical instrument that allows it to be set in [altitude](#) and [azimuth](#). The term is also used to describe the horizon [co-ordinate system](#) which uses these two parameters.

altitude

Above the ground.

anaphoric (clock):

a clock with a dial face like an [astrolabe](#), showing [seasonal hours](#).

ante meridiem (a.m.)

Before [noon](#).

analemma

In modern usage it is a graphical plot with the [Equation of Time](#) on one axis and the sun's [declination](#) on the other. In appearance, a tall thin figure of eight. The dates of various points around the curve are often shown. The shadow of a point falling onto an arbitrary plane at the same [clock time](#) each day will trace out an [analemma](#) over the course of a year. Normally seen on the [noon line](#) of a dial, but can be on any [hour line](#). The exact appearance of the analemma will depend on the plane upon which it is projected.

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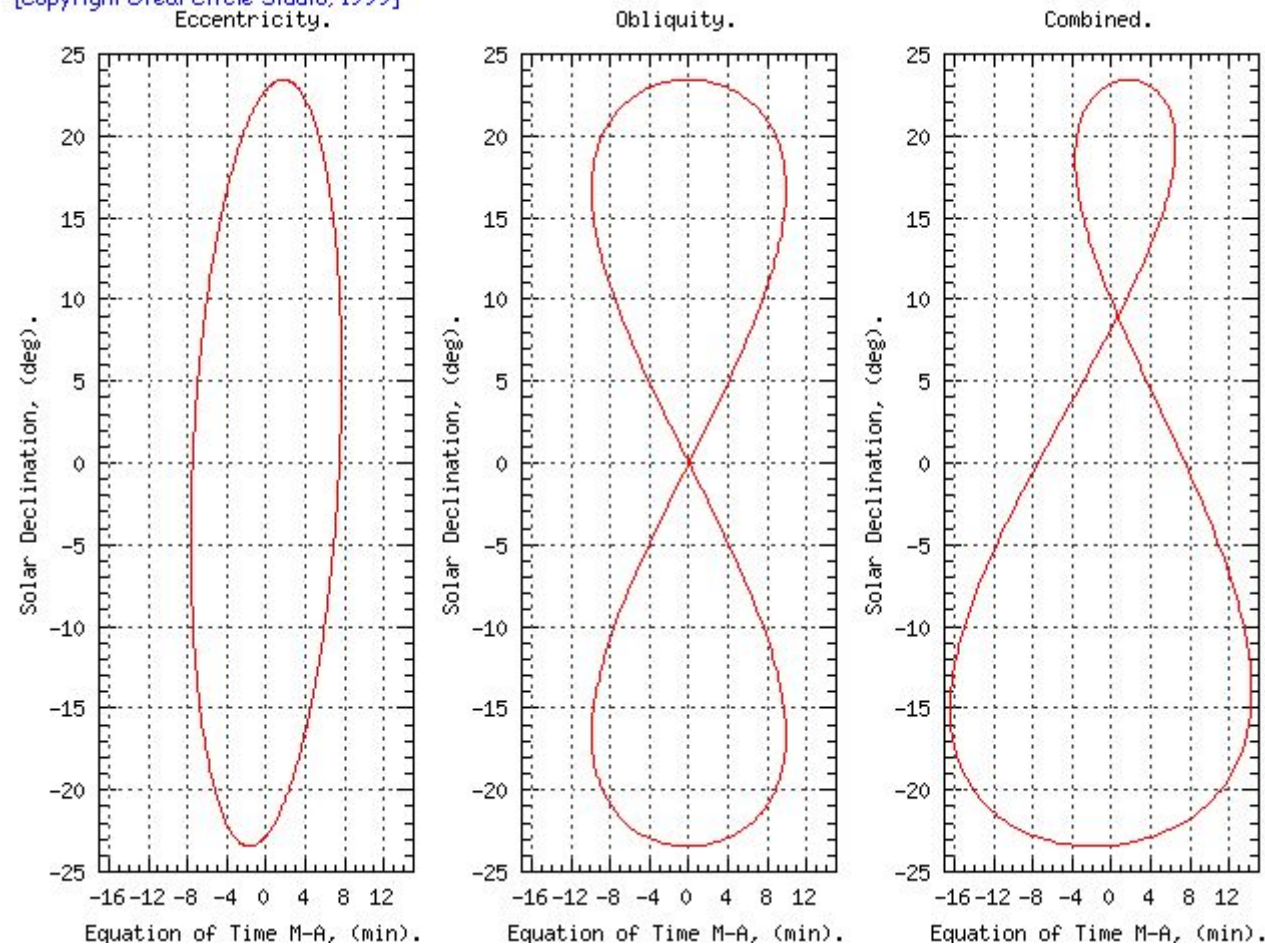


Figure 2.

The components of the analemma

The word analemma has had several other meanings in the history of astronomy and dialling. In the first century BC, the Roman engineer Vitruvius used the word to refer to a graphical construction, equivalent to today's [orthographic projection](#). In the second century AD Ptolemy used analemma to mean an instrument acting as a nomograph for defining the angles of a dial. The use of a modern analemma on a dial dates to around 1640, and the first treatment in English was by Samuel Foster in 1654.

P>angle: (units of measurement) may be decimal [degrees](#); degrees, [arc-minutes](#) and [arc-seconds](#); [radians](#) ($2 \text{ radians} = 360^\circ$); or (seldom, military equipment) [mils](#) ($6400 \text{ mils} = 360^\circ$); or (very rare) [grade](#) (1/100th of a right angle). Preferred notations are: [dd.dd° or dd° mm' ss"]. Note that trigonometric functions in computer spreadsheets (e.g. Excel™) are always defined in radians. The mathematical convention is that positive angles are measured

counter-clockwise, usually with the zero angle position in the 3 o'clock direction or along the x-axis (see [cartesian co-ordinates](#)). In dialling, it is more common to measure angles counter-clockwise from the [noon line](#), although some authors measure from the [sub-style](#) line.

Antarctic Circle

The parallel of [latitude](#) at 66° 34' S. Note that this defines the northern limit of the region around the S pole having at least one day a year with no night.

antisolar point

The point on the [celestial sphere](#) directly opposite the sun's position.

aperture

A small transparent hole in an opaque surface, designed to let a small beam of [sunlight](#) through to fall on a [dial plate](#) or [alidade](#) e.g. for [noon dials](#), [ring dials](#) and [heliochronometers](#).

aphelion

The point where the Earth's [orbit](#) takes it furthest from the sun. It occurs during the first week of July.

apogee

Orbit when it is furthest from the Earth.

arc

A curve which is part of the circumference of a circle.

arc-minutes

An angular measure equal to 1/60th of a [degree](#). Preferred notation [['] or arcmin].

arc-seconds

An angular measure equal to 1/60th of an [arc-minute](#). Preferred notation [^{''} or arcsec].

Arctic Circle

Parallel of [latitude](#) at 66° 34' N. Note that this defines the southern limit of the region around the N pole having at least one day a year with no night.

Aries (first point of)

See [equinoxes](#).

armillary sphere

A skeleton model of the celestial sphere with rings representing the equator, tropics etc. Often finely made in brass, but versions in wood with paper scales were common in 19th century France. It is also the basis of a form of dial – see [armillary](#), dial (types of).

ascendant

Rising towards the [zenith](#). Note: astrologers have a different definition.

astro compass

See [solar compass](#).

astroid

A mathematical curve which is formed by the envelope of a series of straight lines, and has the equation: $x^{2/3} + y^{2/3} = 1$. In dialling, it is the shape of a vertical gnomon used in the latitude-independent [astroid](#) dial. The astroid curve is also one branch of the shape which is traced out by a point on the circumference of a circle as it rolls inside a circle of four times the radius.

astrolabe

An early astronomical instrument in the form of a heavy disk (the [mater](#)) which was suspended vertically and had an angular scale marked around it (the [limb](#)). A coplanar [klimate](#) and an [alidade](#) rotated about its centre. A fretted [rete](#) gave the positions of the brightest fixed stars. The various components were held on the central pivot (the pin or axis) by a small wedge or horse; sometimes dog.

The **planispheric** ~ represents the [celestial sphere](#) by a two-dimensional [stereographic projection](#), showing the position of the sun and major stars at different times and dates, as well as different latitudes. A separate plate is required for each latitude. It was probably a Greek invention of the 2nd century BC, but it was developed extensively by the Islamic cultures from the 9th century AD. It fell out of use in the late 17th century in the west.

The **universal** ~ uses modified projections of the celestial sphere so that they are latitude-independent. The Gemma Frisius type (developed in the west in the early 16th century) retains the stereographic projection but moves the centre to the [First point of Aries](#). The Rojas type (by J. de Rojas of Sarmiento, 1550) uses an [orthographic projection](#) with a projection point at infinity. The La Hire type (late 17th century) moved the projection point in an attempt to make it easier to read.

The **mariner's** ~ is a much-simplified instrument designed to measure the sun's altitude, using an open frame and weighted at the bottom to make it more stable onboard ship; it is a precursor to the sextant.

See [Appendix X](#) for further astrolabe terminology.

astronomical triangle

The spherical triangle on the [celestial sphere](#) whose vertices are the observer's [zenith](#), the elevated [celestial pole](#), and the position of the Sun (or other celestial body).

atmospheric refraction

See [refraction](#).

autumnal {or fall} equinox: see [equinoxes](#).

axis (of the Earth's rotation)

Or **polar axis**: the line running through the true North and South [poles](#) about which the Earth rotates.

azimuth

(of the sun): **[A, AZ]** the angle of the sun, measured in the horizontal plane and from true south. Angles to the west are positive, those to the east, negative. Thus due west is 90° , north is $\pm 180^\circ$, east -90° . It is part of the [horizon co-ordinate system](#). See [Equations](#). Note that navigators (and some astronomers, but not [Meeus](#)) measure azimuth or bearings clockwise from the no

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B

back-staff: an old instrument for measuring the [altitude](#) of the Sun while facing away from it. The **Davis quadrant**, designed by the English captain John Davis, is actually a form of back-staff.

bay

(or bay en imy wenut): literally a “palm rib of the observer of the hours”. It was an ancient Egyptian instrument or sighting device, used in conjunction with a [merkheth](#) to observe and time [transits](#).

Beltane {Beltaine}: an ancient Celtic festival held on the 1st of May, when bonfires were lit. It is one of the [cross-quarter days](#)

bissextile

A [leap-year](#) (from bis sextus dies, or doubled 24 February).

blue moon

There are at least two possible meanings. It can mean a second full moon in a given calendar month. It seems that this “meaning” was accidentally invented by Sky and Telescope magazine in 1946, but it has passed into wide usage. Alternatively, it may mean that the Moon actually has a blue coloration, due to smoke or other aerosols in the atmosphere. Both phenomena are rare (the second more so), hence the expression “once in a blue moon”.

brachiolus

From the Latin for “little arm” it is a movable arm which acts as a suspension point for a cord on a [card dial](#).

break of day: see [daybreak](#).

British Summer Time [BST]

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C

Candlemas: the festival of the purification of the Virgin Mary, on 2nd February. It also corresponds to the Celtic festival of [Imbolc](#), and is a [cross-quarter day](#).

calendar

A system for counting days and defining the [date](#).

Campbell-Stokes

See [sunshine recorder](#).

Cancer

See [tropics](#).

canting out

See [wedging out](#).

Capricorn

See [tropics](#).

cardinal point

With the [horizon](#). Note that the Latin terms are Septentrio, Meridies, Oriens and Occidens, so that a compass rose on a mediaeval dial simply identifying “S” is ambiguous.

cartesian co-ordinates

See [co-ordinates](#)

celestial equator

The intersection of the extended plane of the Earth's [equator](#) with the [celestial sphere](#).

celestial latitude

See [ecliptic latitude](#).

celestial longitude

See [ecliptic longitude](#).

celestial pole

The points on the [celestial sphere](#) where it meets the Earth's [axis](#). The stars appear to rotate around these poles.

celestial sphere

An imaginary sphere, arbitrarily large and co-centred with the Earth, on which all the stars appear to be fixed.

centre (of a dial)

The point where all the [hour lines](#), and a polar-pointing [style](#), meet. This point does not always exist (e.g. on [polar dial](#) and [direct E or W dials](#), the lines meet at infinity). In simple [horizontal](#) or [vertical dials](#), this point coincides with the root of a (thin) [gnomon](#). In the case of a thick gnomon having two styles, there are two centres to the dial. The centre is often, but not necessarily, the [origin](#) of the co-ordinate system used to describe the dial. See [Figure 1](#).

chapter ring

The ring on a dial face carrying the hour numerals. The term is more widely used for clocks, but it also finds use, for example, on dials with several separate rings for different locations.

chilindrum

See [Dial \(types of\)](#); cylinder ~.

civil time

See [Time \(types of\)](#) civil~.

clinometer

An instrument for measuring the [inclination](#) or slope of a surface. Also called an [inclinometer](#).

cloisonné

A term sometimes used to describe the technique of making metal dials by deeply etching the lines and numerals and then filling them with coloured material. It derives from the jewellery method of separating enamels into shallow compartments with metal edges.

co-latitude

Equals $90^\circ - \text{latitude}$.

compass bowl

A bowl sunk into the [dial plate](#) of a (portable) [horizontal dial](#) to house a magnetic compass.

compass rose

A drawing of the compass directions, showing as a bare minimum the [cardinal points](#), but more usually eight, sixteen or thirty-two points.

compendium

Normally used to describe a collection of scientific instruments in one case. Also, **Compendium**: the journal of the NASS.

conic section

Any of the range of geometric curves produced by the intersection of plane with a cone (i.e. circles, [ellipses](#), [parabolas](#) and [hyperbolas](#)).

coordinates: a system of measurements used to describe any point in two or three dimensions.

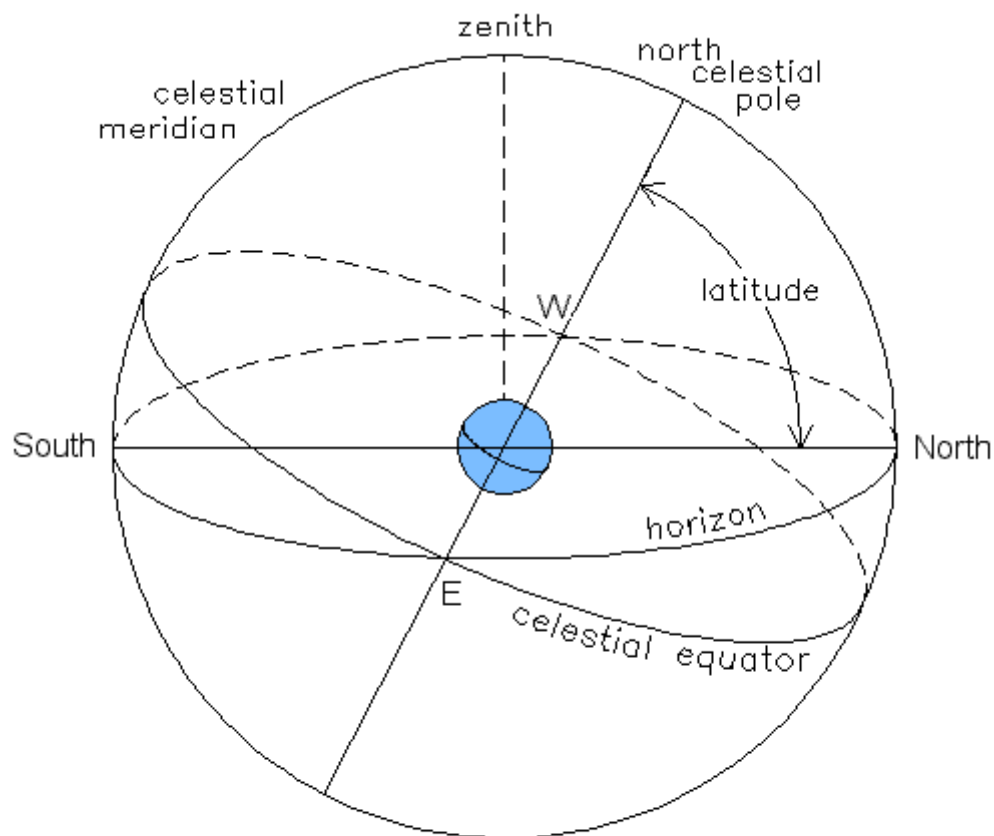
Co-ordinate Systems:

Cartesian ~ [x,y,z]

in which the axes are mutually perpendicular, are normally used for positions of points within a dial. For simple [horizontal dials](#) the preferred axes have x increasing to the E of the [dial plane](#), y increasing to the N of the dial plane and z (in 3-D only) increasing perpendicularly to the dial plane (upwards). For vertical and other plane dials, x increases to the left, y increases downwards, and z perpendicular to the plane in the direction towards the observer. The [origin](#) of the system must be defined explicitly. Note that these definitions produce a conventional right-handed co-ordinate system, and are also those used by the [Zonwvlak](#) programs.

ecliptic ~

[β , λ , ϵ] or [ELAT, ELON] the system of ecliptic (or celestial) [latitude](#) and [longitude](#), defined with respect to the [ecliptic](#) and the [celestial poles](#). Ecliptic co-ordinates predominated in Western astronomy until the Renaissance but, with the advent of national nautical [almanacs](#), the [equatorial system](#), more suited to observation and navigation, gained ascendancy.



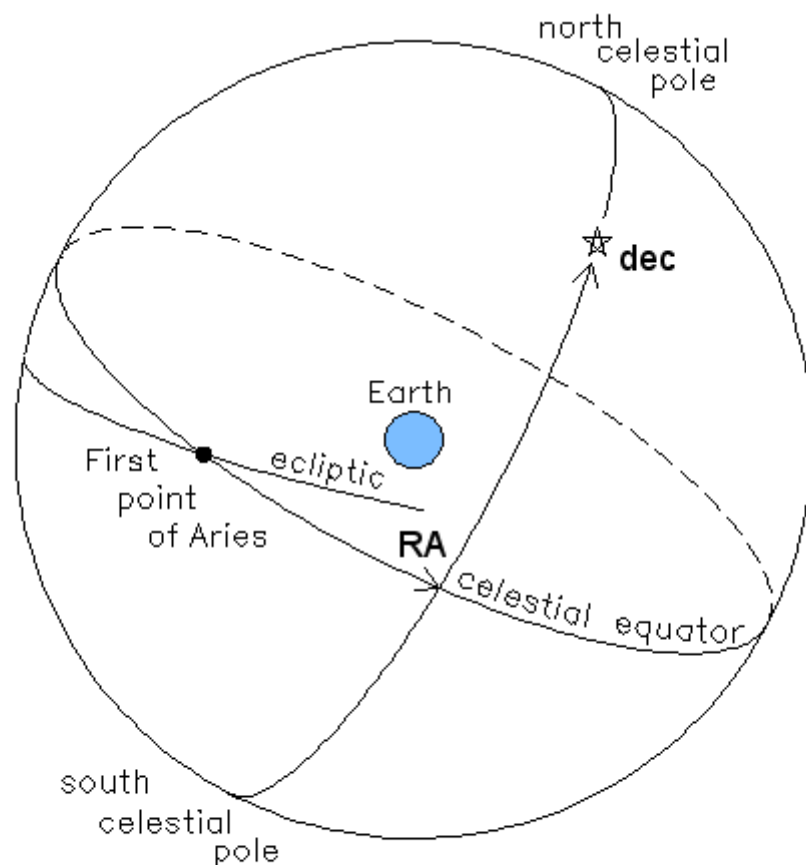
Celestial coordinates as seen by an observer in mid-northern latitudes

Figure 3.

Celestial co-ordinates seen by an observer in mid-northern latitudes.

equatorial ~

: **[a, d]** or **[RA, DEC]** is the most common astronomical co-ordinate system and is defined by the **celestial equator** and **poles**. The **right ascension** and **declination** are directly analogous to terrestrial **latitude** and **longitude**.



The equatorial system of celestial coordinates, showing the right ascension (RA) and declination (dec) of a star.

Figure 4.

The equatorial system of celestial co-ordinates, showing the right ascension (RA) and declination (dec) of a star.

galactic ~

: is used for studying the structure of the galaxy. It is unlikely to be encountered in dialling.

geographic ~

[f, ?] or [Lat, LON] the standard method of determining any location on the Earth's globe, using [latitude](#) and [longitude](#).

horizon ~ system

[a,A] or [ALT,AZ] the simplest celestial co-ordinate system, it is based on [altitude](#) and [azimuth](#). It is fundamental in navigation as well as in terrestrial surveying. However, for specifying the position of the Sun or other celestial bodies, other co-ordinate systems fixed with respect to the [celestial sphere](#) are far more suitable.

Ordnance Survey co-ordinates

Of the datum point at the bottom left of the map. Note that the OS maps on which the co-ordinates are based use the transverse [Mercator](#) projection, with a projection origin at 49° N; 2° W.

polar ~

:**[r, ?]** an angle-based co-ordinate system sometimes used for defining points on a dial plane, where *r* is the distance from the origin and ? is measured anti-clockwise from the S. Note: navigators also make use of polar co-ordinates and usually define them as (*?*, *r*).

Ptolemaic co-ordinates

[hec, hor]: an angular co-ordinate system loosely based on the geometry of [Ptolemy](#).

terrestrial :

See [geographic ~](#).

End of Co-ordinate systems

cross: for a discussion of the cross sometimes seen on the noon line of a dial, see [noon cross](#) and [cross patty](#).

cross-quarter days: days which are (approximately) midway between the [Quarter days](#), hence dividing the year into eight parts. They are occasionally used instead of the [zodiac](#) signs for [declination lines](#) on dials, and have become adopted as modern celebrations or holidays. See Appendix XII for their names and dates.

cross patty{c. pattée or c. formée}: an heraldic term for a form of square cross shape () sometimes seen instead of XII on the [noon line](#) of dials. It is perhaps the most common of the [noon crosses](#).

cross-staff: a simple instrument for determining the [altitude](#) of a celestial body. A cross piece or [transom](#) is moved along a staff, calibrated with a cotangent scale, and sighted by eye against the body and the [horizon](#). Old illustrations often show a ~ with three transoms fitted but, in use, only one would be used at a time. Also called a **fore-staff** or **Jacob's staff**.

culmination (of the sun): to lie on the [meridian](#) or, in more general language, to reach its highest point. Equivalent to the [superior transit](#). From the Latin "culmen", meaning summit.

cursor: a part of a mathematical instrument which slides backwards and forwards over a scale.

cusp: (astrological) the initial point of an astrological [house](#) or [sign](#).

cycloid: (pron. si-cloy-d) a geometric curve which is traced out by a point on the circumference of a circular disk rolling (without slipping) along a straight line

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D

daeg mael:

one of the Anglo-Saxon [tides](#), it may also have been the word for a dial in the early Anglo-Saxon period.

dagsmork

An Icelandic term ('daymarks') referring to landmarks in the countryside which, when viewed from a fixed location, indicated the direction of the Sun at fixed times of the day.

date

A single day in a chosen [calendar](#) system. Note that the agreed international date system (and British Standard 4795) specify "year, month, day" – for example 1951 August 10. Common UK usage is the reverse of this – beware the illogical American usage of month, day, year, especially in all-numeric forms.

Date Line

See [International Date Line](#).

dawn: the first light of day, taken as the onset of morning [twilight](#).

day

The period for one rotation of the Earth. **Solar** ~ : measured between successive [transits](#) of the sun: **Mean solar** ~ : measured between successive [transits](#) of the fictitious mean sun. Equal to 24 hours, it is the usual meaning of ~ unless it is further qualified. **Sidereal** ~ : measured between successive transits of the [First point of Aries](#) (or, in everyday language, any 'fixed' star). A sidereal day is 23 hours 56 minutes 4.1seconds. Beware the possible confusion between day and [daytime](#).

daybreak (or **break of day**): an old term for first light, usually taken as the onset of astronomical [twilight](#).

daytime

That period of a day between sunrise and sunset.

Daylight Saving Time

See [time \(types of\)](#).

declination

(of a wall) {sometimes called the **declining angle** or the **deviation**, to avoid confusion with the *sun's* [declination](#)}: [**d**, **DEC**] the angle, measured in a horizontal plane, that a wall's perpendicular makes with due south (i.e. a wall facing S has $d = 0^\circ$). Walls declining westward have positive declinations, those eastward, negative. Beware – this is not a universal convention and some authors define the angle with respect to the nearest [cardinal point](#) of the compass.

declination

To locate other celestial bodies. See [Figure 1](#) and [Equations](#).

declination lines:

lines on a dial showing the sun's declination on a particular date. They are read by observing the shadow of a [nodus](#).

degree:

[$^\circ$ or deg] an angle equal to 1/360 of a complete circle.

descendant

Falling from the [zenith](#). Note: astrologers have a different definition.

diagonal scale

A device for interpolating between scale divisions, pre-dating the [vernier](#) scale. It is constructed by drawing diagonals between individual divisions across a wide band, with a series of equi-spaced arcs parallel to the main scale crossing them. It is read by noting the position of the [fiducial line](#) with one of these arcs. Most usually found on astronomical instruments, a similar design was used by Sir Christopher Wren for indicating the minutes on his famous vertical dial on All Souls' College, Oxford.

dial:

A Middle English word, apparently deriving from the Latin 'dies' though the medieval Latin 'dialis', used for what is now called a [sundial](#). It later became used for many types of indicators, hence the necessity (from 1599) for the qualifying 'sun' prefix. The word ~ in modern English has now become common again as a shortened version of sundial. Hence **dialling** {dialing}, the art and science of designing and constructing dials; **diallist** {dialist}, one who designs or makes dials.

Dial types:

Ahaz (Dial of Ahaz)

: supposed [refraction](#) dial, from the Bible story (Kings 20 v8-11) which may allude to a dial showing time running backwards.

altitude ~

Any dial which uses the sun's [altitude](#), rather than its [azimuth](#), for indicating the time. Usually does not need to be aligned N-S. Examples are [ring dials](#), [flag dials](#), and [shepherds' dials](#). Altitude dials were also often incorporated in [quadrants](#) and folding rules.

analemmatic ~

. Most usually found set in the ground in parks, where the observer acts as the gnomon. Note that some of these dials show an [analemma](#) drawn about the gnomon positioning line. This is a method of indicating the [EoT](#) for the appropriate date, but it must be remembered that the gnomon is not positioned on the analemma. The analemmatic dial may be regarded as a projection of the [universal equatorial ring dial](#). Analemmatic dials were once common paired with a horizontal ~ in a self-orienting portable [compendium](#).

analemmic ~

This term has sometimes been used to describe dials which have an [analemma](#)-shaped [gnomon](#), or analemmas on the [hour lines](#), enabling them to read [mean time](#). Note, the dials have no direct link to [analemmatic](#) ones.

Anglo-Saxon ~

{sometimes just **Saxon ~**}: a sundial from the Anglo-Saxon period (c 650 – 1050 AD); designed to show [unequal hours](#), or the basic [tides](#), with a horizontal [gnomon](#). Similar to the [mass dials](#) which superseded it, a Saxon ~ shows much higher levels of craftsmanship and is often finely decorated. Also, it is invariably engraved in a separate (circular or rectangular) stone, not into a pre-existing wall. Saxon dials are often taken to be the precursors to the later [scientific](#) dials. In the early part of the period the semicircle was divided by five lines into four segments. During the latter part of the period it was subdivided into eight or twelve segments and the dial sometimes carried an inscription in Old English. Throughout the period the principal lines had a cross bar near the perimeter giving the appearance of Latin crosses. See [Appendix II](#) for the basic time periods shown on the dial.

antiboreum

An ancient form of dial in which a partial-sphere is hollowed into a stone, and a ray of sunlight enters the partial-sphere through a south-facing pinhole through the stone.

armillary

And the other the local [meridian](#). Usually, other [great circles](#) are added representing the [Prime meridian](#) and the [ecliptic plane](#), sometimes together with small circles for the [tropics](#) and [arctic circles](#). These add artistically, but detract from its clarity as a dial. The gnomon sometimes carries a [nodus](#) at the centre of the sphere; this may be used for indicating the date.

astroid ~

A ~ which uses the [sun's declination](#), [altitude](#) and [azimuth](#) to give the [hour angle](#). It is latitude-independent, and is named after the geometric [shape](#) which forms its gnomon.

auxiliary ~:

A small [equatorial dial](#) used as a mechanical aid to constructing dials on other planes (particularly [vertical decliners](#)) by co-mounting on a common [gnomon](#) and projecting the [hour lines](#). Often used with a [trigon](#).

azimuthal ~

(or **azimuth ~**): any dial which uses the sun's [azimuth](#) for indicating the time. It usually needs to be aligned N-S, and has a vertical style (if it has no dependence on altitude).

Berossos ~

Another term for a [hemispherium](#), named after its inventor Berossus Chaldaeus, a Babylonian astronomer who flourished on the Greek island of Cos around 270 B.C.

bifilar

~: invented in 1922 by Hugo Michnik in its horizontal form, although it can be on any plane. The time is indicated by the intersection on the dial plate, of the shadows of two wires (or other lines in space) stretched above and parallel to it. The wires often run E-W and N-S, with their (different) heights above the plane being a function of the location of the dial. It may have equiangular hour markings, and hence can be delineated to show many kinds of hours.

Bloud ~

A portable, *magnetic* [azimuth ~](#) made mostly in Dieppe by makers such as Charles Bloud.

book ~

{**open book ~**}: a modification of the [polar ~](#), with the [dial plate](#) consisting of two planes set in a vee, with their intersection line lying parallel to the Earth's [axis](#). A polar [gnomon](#) can be placed bisecting the angle of the two planes. Alternatively it may be arranged so that the outer edge of each plane acts as the [gnomon](#) for the other. The term book ~ can also be applied to [diptych dials](#) which are designed to look like a book when closed.

Butterfield ~

A pocket sundial by, or in the style of, Michael Butterfield (Paris, 17th century). Typically it consists of an octagonal silver [horizontal dial](#) with a [gnomon](#) of adjustable angle, often with a bird's head pointer, with several rings of [hour lines](#) for cities of different [latitudes](#). A magnetic compass is fitted in the same case.

cannon ~

See [noon gun](#).

Capuchin ~

A latitude-specific [card dial](#), related to the [Regiomontanus dial](#). So-called because the outline of the hour-lines is said to resemble a hooded Capuchin monk.

card

~: a class of [portable dials](#) built on a single plane, e.g. a card which is suspended in the vertical plane. They usually have a sun sighting device along one edge, and a cord with a bead which hangs vertically below a movable suspension point.

ceiling ~

{also known as a **mirror ~** or **reflected ~**}: a dial marked on a ceiling where the time and date are indicated by a beam of sunlight reflected from a small horizontal mirror placed on a windowsill.

chalice ~

(or **cup, bowl** etc.): a form of [refraction ~](#) where the hourlines are drawn on the inside of a drinking vessel. Early examples, often in precious metals are rare and valuable.

Chinese ~

: a wide range of dials have been used in China, from the vertical gnomon of the mythical astronomer Xi, through [equiangular ~](#) with sun-pointers and 100-segment time scales from the 1st – 2nd centuries BC, [equatorial dials](#) for equal hours in the Ming dynasty (1368 to 1664), to conventional horizontal dials in the 19th century.

compass ~

A [portable](#) horizontal dial with an accompanying compass to allow it to be correctly oriented. The compass is often below the pierced dial plate, and the gnomon is hinged for packing. Beware: the term compass dial is often used to mean a [magnetic dial](#).

complementary

~: a (hypothetical) horizontal ~ used as an aid to designing a vertical declining and/or reclining dial. Its [gnomon](#) and [hour lines](#) are calculated not for the site of the proposed (real) dial, but for the location where the Earth's surface is parallel to the [dial plate](#) of the proposed dial. For a simple [direct south](#) dial, the complementary dial would be located at the [co-latitude](#).

cone

~: a term used to describe several entirely different types of dial. (a) a class of dials where the [dial plate](#) is an inverted, truncated cone, giving dials similar to a [scaphe dial](#) or a [hemicyclium](#), or (b) a class of modern dials which use a cone lying on its side as the [gnomon](#). Many varieties, including [sidereal](#), exist.

cross ~

A dial in the form of a cross, usually of stone, with the “front” surface of the cross parallel to the [equatorial plane](#), and the top pointing south. The side surfaces of the cross can each form a [dial plane](#), with its [gnomon](#) being a corresponding edge of the cross itself. Usually found as churchyard memorials. Rare. [Portable](#) cross dials have the long arm parallel to the polar [axis](#) and the short arm E-W.

cube ~

A (set of) dials on the surfaces of a cube. There may be up to 6 dials, but more often 5 e.g. direct N, S, E, and W, together with a [horizontal](#) on the top surface. Alternatively, it is possible to set the cube so that its top surface is parallel to the equatorial plane, i.e. the base makes an angle equal to the [co-latitude](#) with the horizontal. Both portable (usually adjustable) and monumental versions are known.

cycloid (polar) ~

A variation of the standard [polar dial](#) in which the gnomon has a [cycloid](#) shape, with the result that the [hour lines](#) are equally spaced.

cylinder ~

A [portable, altitude dial](#) in which hour lines for different dates are delineated around the surface of a cylinder, which is allowed to hang or stand vertically. A horizontal [gnomon](#) projects radially from the top of the cylinder, and is adjusted to the appropriate date around its periphery. Sometimes two gnomon are supplied; a long one for winter and a short one for summer. The dial is held with the gnomon facing the Sun so that the shadow falls vertically. Latitude specific. This was the **chilindrum** of Chaucer's monk.

declining ~

A [vertical dial](#) which does not face any of the [cardinal](#) points of the compass. The [sub-style](#) will be displaced from the [noon line](#), although the latter will still lie vertically below the [dial centre](#).

diametral ~

One of the [equatorial projection dials](#), first described by Samuel Foster of Gresham College in the 17th century, it is a horizontal dial with a moveable [style](#) and hour points which lie along a straight line lying E-W.

diffraction ~

A dial invented in 1999 by M. Catamo & C. Lucarini. It has no [gnomon](#), but the [dial plate](#) consists of a circular [diffraction](#) pattern, which forms a bright, multicoloured diametrical line pointing at the Sun when viewed perpendicularly to the centre of the dial plate. Horizontal, altitude and equinoctial versions are possible. The dial plate is usually made from a CD (compact disc), hence "**CD dial**".

digital ~

An ingenious 20th century dial. The "gnomon" consists of a rectangular sandwich of shadow masks set parallel to the [polar axis](#). This gnomon casts a shadow in which digits representing the time are sunlit. Patented, and requires great precision in manufacture.

diptych ~

Dial in which a [vertical](#) and [horizontal](#) dial are hinged together, and a common cord [gnomon](#) running between them also ensures that they open to a right angle. Latitude specific. This term is, confusingly, sometimes also used to describe a monumental [open book](#) dial.

direct ~

A [vertical dial](#) which directly faces one of the [cardinal points](#) of the compass e.g. direct S.

double horizontal ~

A horizontal dial with (usually) a combined polar pointing [gnomon](#) and a vertical one showing the time/date on a [stereographic](#) projection of the sky onto the horizontal plate. Capable of self orientating, although normally fixed in position. Usually attributed to William Oughtred in the early 17th century, early hand-engraved versions are very fine.

Egyptian ~

A range of sundials from ancient Egypt (portable and fixed) exists, the earliest being from the time of Tuthmosis III (1479-1425 BC). The portable devices appear as a long, thin 3-D letter “L”, laid with the long shaft horizontal along the sun’s [azimuth](#), with the upturned foot casting a shadow onto the shaft. It is very similar to the [merkheth](#) but has a dedicated hour scale

equant ~

A modified [horizontal](#) ~ in which the [hour-lines](#) are replaced by [hour points](#). These points are arranged round a geometric curve chosen so that the points are equally spaced, allowing the use of a [vernier](#) scale and more accurate interpolation of times. Not related to [Ptolemy’s equant point](#).

equatorial ~

A dial in which the [dial plate](#) is set parallel to the [equatorial plane](#) and the polar-pointing [gnomon](#) is perpendicular to it. The dial has [hour lines](#) equally spaced at 15° intervals around the gnomon, and hence the dial plate may be rotated to account for [EoT](#), [longitude](#) and [BST/DST](#) corrections. Sunlight falls on the underside of the dial plate from the [autumnal equinox](#) until the vernal equinox. For this period, the gnomon must project below the dial plate, which is delineated on both sides. An alternative form replaces the dial plate by a narrow hour ring (or half-ring) allowing the scale, inscribed on its inner circumference, to be read throughout the year. With this form, special analemma-shaped gnomons can be used to show [mean time](#). Note: some authorities insist that this dial should be called an [equinoctial](#) ~.

equiangular ~

A term used for dial types where the [hour points](#) are placed at equal angles (15°) around a circle (or part of). If the [dial plane](#) is not parallel to the [equatorial plane](#), the mounting of the gnomon, (which does not need to be polar) must be movable to accommodate this.

equatorial projection ~

: a class of dials obtained by projecting a [universal equatorial ring dial](#) onto any plane. Members of the class include [analemmatic](#), [diametral](#), [Foster-Lambert](#) and [Parent](#) dials.

equinoctial ~

Name for an [equatorial](#) ~, preferred by some authors.

flag ~

An [altitude](#) ~, formed by “unwrapping” the scale of a [shepherd’s](#) ~ into a flat plane which can be shaped like a flag or pennant and is positioned perpendicular to the sun.

Foster-Lambert

~: a form of [equatorial projection dial](#), with the projection arranged to produce a circular ring of equiangular [hour points](#). A good example is the large reclining dial (now back at Herstmonceux Castle after a period at Cambridge) designed in 1975 by Gordon Taylor for the Royal Greenwich Observatory.

geographical ~

A dial in which the dial plate shows a map of the world, with curved hour lines allowing the time at any location to be indicated.

globe ~

. where the shadow of a movable point on the surface is made to fall on the centre of the globe.

Graeco-Roman ~

: a general class of dial from about the 3rd century BC (Greek) to the 4th century AD (Roman). Made of stone, they include the [hemispherium](#), the [hemicyclium](#), and some conical dials.

great decliner

Usually indicates a [declining dial](#) which nearly, but not quite, faces E or W. The [centre](#) of the dial falls off the [dial plate](#) and, as a consequence, it does not show a noon line.

hâfir dial

An Islamic dial with [unequal](#) hours, vertical [gnomon](#) and equiangular date scale of 12 segments.

halazûn dial

An Islamic dial with [unequal](#) hours, vertical gnomon and a date scale of 6 segments (each representing two signs of the zodiac).

hat ~

: an [altitude dial](#) comprising a circular disk mounted concentrically on top of a vertical cylinder. The dial is read by the minimum vertical length of the disk’s shadow on the outside of the cylinder.

heliochronometer

A [precision](#) sundial which incorporates some means to allow it to read [civil](#) (or [mean](#)) time. This is usually achieved by incorporating an [EoT](#) cam (as in the Pilkington and Gibbs heliochronometers), or by projecting a spot of light onto an [analemma](#).

Note: some authors use this term to describe any precision sundial.

hemispherium

An ancient dial with the [dial surface](#) formed by a hemisphere hollowed into a horizontal (or occasionally vertical) stone face. The [gnomon](#) is a vertical spike (length equal to the radius of the sphere) set in the bottom of the hemisphere. It is essentially a horizontal [altitude dial](#), with a shaped dial plate which prevents [sunrise and sunset](#) being at infinite distances.

hemicyclium

Similar to the [hemispherium](#), but with the south-facing part of the hemisphere cut away, and with the [gnomon](#) now projecting horizontally from the N edge.

horizontal ~

The common or garden sundial with a horizontal [dial plate](#) and polar-pointing [gnomon](#). Latitude specific.

inclining ~

Usually applied to [portable dials](#) in which a [horizontal dial](#), designed for a high [latitude](#), typically 60°, may be inclined by raising its southern edge (in the N hemisphere) so that it may be used at locations with lower latitudes. The opposite arrangement is also sometimes found. The term is also sometimes confusingly used for near-vertical dials where the top leans away from the observer.

Islamic ~

A ~ with [unequal hours](#) and showing the Islamic prayer times.

Lambert

~: see [Foster-Lambert ~](#).

Little Ship of Venice

. A portable dial in the shape of a Venetian ship with a central mast. Based on the [Regiomontanus dial](#), the few early examples are valuable.

magnetic ~

{or **magnetic compass ~**} : a small [portable ~](#) in which a complete [horizontal ~](#) is mounted on a compass card, and hence is self-orienting. In principle, the magnetic variation of the place and date where it will be used can be accommodated by rotating the dial from the magnetic N-S line of the compass. Beware: this type of dial is sometimes described as just a [compass dial](#).

magnetic azimuth ~

A [portable ~](#), usually in [diptych](#) form. There is no [string gnomon](#) but instead the lid is lined up to fall exactly on the base, the time being read from the compass needle on a [chapter ring](#). The chapter ring position is moved in a N-S direction from a calendar [volvelle](#) on the under side.

mass ~

. Delineated, probably empirically, to show some form of [unequal hours](#), there is a huge variety of design types. Some are event markers rather than true sundials.

mechanical universal equinoctial ~

(sometimes **minute ~**): a ~ that uses gearing to show accurate time on a clock face, i.e. a [solar clock](#).

mirror ~

A ~ having no gnomon, but using a small, appropriately angled mirror to reflect a small spot of sunlight onto the dial face. The dial may be on a vertical wall facing N or within a building. See also [ceiling dial](#) or [reflecting dial](#) (separate definitions).

monofilar ~

A ~ in which time is marked by the point where the shadow of a thread (or other thin [gnomon](#)) held between the dial face and the Sun intersects a set of date lines.

moon ~

A sundial calibrated in some way so that it can tell the time by [moonlight](#). No change to the basic dial is required, but a correction factor for the time is required which accounts for the age or [phase of the Moon](#). Never very accurate because of the complex nature of the Moon's orbit, they generally require a nearly full Moon to be able to be read clearly. Purpose-built moon dials have either spiral hour lines or a table of moon phases (as in the famous Queens' College, Cambridge, dial).

multiple ~

Simply more than one dial physically incorporated into the same dial structure.

multiple gnomon ~

A ~ in which there is a separate shadow casting element (gnomon) for each [hour line](#). The elements can be points, lines or planes.

navicula de Venitiis

See Dial Types ([Little Ship of Venice](#))

noon (or meridian) dial or line

A dial which has only one [hour line](#), for [noon](#). It has a [nodus](#) rather than a full [gnomon](#). This may be in the form of a small ball on the end of a shaft or, more usually, an aperture in a plate or window opening into a building. Very long, accurately-levelled meridian lines (running N-S) built into cathedrals were intended for the accurate determination of the [equinoxes](#), [solstices](#) and other solar parameters. A **noon dial** (as opposed to noon line) is usually taken to mean a complete noon [analemma](#), possibly including dates.

noon gun

A small cannon mounted such that focussed sunlight from an appropriately angled lens falls on the touch-hole and fires the gun at [noon](#). A novelty rather than an accurate time indicator.

noon mark

A stone, or line marked on a stone, set to receive the noon shadow of a building or other feature. The term is, however, often used interchangeably with a [noon ~](#).

Nuremberg ~:

a loose collective term used for the [diptych dials](#) made around Nuremberg, Germany, during the 16th and 17th centuries. The majority were made of ivory, featured a compass bowl in the lower leaf and had a [string gnomon](#).

Oughtred ~

Another name for a [double horizontal dial](#).

Parent ~

A form of [analemmatic ~](#), with the [dial plane](#) parallel to the Earth's axis so that the ellipse of hour points becomes a segment. First designed by Parent in 1701.

pelekinon

~: a form of ~ attributed to the Greeks around 100 BC. In appearance, the dial resembles a butterfly or double-headed axe, and was delineated to show [unequal hours](#).

pillar ~

See [cylinder ~](#). Sometimes also confusingly used to describe monumental dials mounted on tall pillars.

poke ~

An old term for a pocket or [portable dial](#).

polar ~

A ~ in which the [dial plate](#) is set along the E-W direction and reclines so that it is parallel to the [polar axis](#). The standard polar-pointing [gnomon](#) is thus also parallel to the dial plate. Simple to construct, but the hour lines disappear to infinity when the Sun is in the plane of the dial. For a south-facing polar dial, the theoretical limits at the summer solstice are 6am to 6pm.

polarised light ~

A gnomon-less dial which detects the orientation of the [polarised](#) skylight. Its polariser/analyser system is best arranged to view a region of the sky near the N [celestial pole](#) (S in the southern hemisphere), allowing the [hour lines](#) to follow a standard 15° per hour scale. Although not particularly accurate, it has the advantage that it does not require direct [sunlight](#) to work as long as there is clear sky towards the N celestial pole. Thought to have been invented by Sir Charles Wheatstone in 1848.

polyhedron ~

A multiple dial in the form of a solid polyhedron, with a separate dial on each face. Usually each dial is some form of [decliner/recliner](#), but may include [scaphe](#) and [polar dials](#) as well. Particularly common as the monumental Scottish stone lectern and obelisk dials.

portable ~

Simply a dial meant to be moved from place to place, either as a pocket dial or simply being transportable. In most forms, some means of orienting the dial is included, and they are often either [universal](#) or capable of being read at a number of fixed [latitudes](#).

prism

~: a term occasionally used to describe a [multiple dial](#) with two or three dial faces set on the sides of a triangular prism.

proclining ~

A term sometimes used to describe a dial which is approximately upright but which leans forward towards the observer. A dial which leans forward by 10° will have an [inclination](#) of $+100^\circ$. They are sometimes also called [inclining](#) dials, although that term is best reserved for dials derived from a horizontal ~.

reclining ~

Strictly, an approximately [vertical dial](#) which leans backwards away from the observer. However, often used as a catch-all term for any non-vertical dial. The angle is defined from the horizontal towards the observer, so a dial which leans backwards by 10° from the vertical has an [inclination](#) $+80^\circ$.

reflecting ~

These dials have no [gnomon](#), but reflect [sunlight](#) by means of a semi-cylindrical mirror, set with the axis of the mirror parallel to the [polar axis](#). The mirror reflects the light to form a caustic curve amongst the [hour points](#). For the special case of the mirror having a [cycloid](#) shape, the hour points are equally spaced. Note that the term reflecting dial may also be used for [ceiling dials](#).

refraction ~

Dials which use a clear liquid in a solid cup to compress the hour lines. Sometimes drawn on the inside of a drinking cup – a [chalice dial](#) – (see [Dial of Ahaz](#)) or on the bottom of a fountain basin or swimming pool. A second form uses a cylindrical lens to focus sunlight onto a [curved dial plate](#).

Regiomontanus ~

A universal form of [card dial](#), usually with the suspension point of the cord movable in two dimensions in the card plane. It is the basis for many other variants of dial.

ring ~ :

A [portable, altitude dial](#) in the form of a ring, with a small [aperture](#) in its circumference. The ring is suspended in a vertical place such that the aperture faces the sun. The time is then indicated on a time/date scale on the inside of the dial. The suspension point may be adjustable on the circumference to allow for [latitude](#) changes. Not very accurate, due to their usually small size and the fact that a very compressed date scale is needed to prevent the ring becoming too wide. These dials were known by Vitruvius in the first century BC. Beware: this term is also sometimes loosely used to describe a [universal equinoctial ring dial](#).

Saxon

~: see [Anglo-Saxon](#) ~.

scaphe ~

. The name comes from the Greek word for boat, and the dial itself is thought to have developed from the [hemispherium](#). Normally with a vertical [gnomon](#).

scientific ~

A term usually taken to mean a dial which is designed to show [equal hours](#), or at least in which the effect of latitude been mathematically accounted for. Thus any dial with a polar-pointing [gnomon](#) is scientific, but, for example a [mass dial](#) is not. Mostly, they date from the 16th century onwards.

scratch ~

See [mass dials](#).

self-orienting ~

Any dial which, when correctly adjusted for the latitude and/or date, can be used to find the direction of south. Sometimes also called “self-southing”.

shadow plane ~

: a class of dial in which the [gnomon](#) is movable and is set by the observer so that it, and its shadow, lie in the sun’s [hour plane](#). The gnomon may be a plane, line or point. The [dial plate](#) can, if required, be any surface. A [globe dial](#) with a movable vane is an example of a shadow plane ~.

shepherd’s ~

See [cylinder dial](#) for the usual meaning. A second type of shepherd’s dial is a set of marks cut in the turf, so that the shepherd’s crook could be used as a vertical gnomon – see Shakespeare’s Henry VI part 3, act 2, scene 5.

sidereal ~

A ~ designed to show [sidereal time](#) by means of introducing a variable offset to the time shown by the solar shadow on an [equiangular dial](#). The dials are rare, with no known public dial in the UK(?)

solar clock (or solar chronometer)

An instrument in which a sighting of the sun, through a movable telescope or open sights, is made to display the time on a clock face by a set of gears. A famous example by Sir Charles Wheatstone is in the Science Museum. Note: this term is often used as a synonym for [heliochronometer](#), but is best reserved for the definition given here.

spherical ~

See [globe dial](#).

spoon ~

A rare form of [scaphe](#) ~ delineated in the bowl of a spoon.

stained glass ~

A (generally vertical) dial in which the [dial face](#) is of stained glass, and is viewed from the back, i.e. through the glass from inside the building. The gnomon remains on the outside of the building, and frequently causes cracking of the glass if supported directly from it. Typically, they were incorporated into church windows in the 17th century, although most are now in museums and there are some notable modern examples.

standing ring ~

A form of [universal equinoctial ring dial](#) mounted on a stand, usually including a compass.

Star of David ~

A monumental dial similar in concept to the [cross dial](#), except that the six-pointed star with 60° angles gives opportunities for numerous dials.

sun clock

See [solar chronometer](#), dial (types of).

tidal ~

A dial delineated to give the times of the marine tides. Based on some form of [equiangular dial](#) (e.g. an [equatorial dial](#)). It bears the compass points in a circle with the names of various ports written against them. The '[establishment](#)' of a port is given as a compass point and, together with the hour markers, indicate the interval of time between the passage of the Moon over the meridian of the port and its high tide. Not to be confused with dials showing the Anglo-Saxon [tides](#).

universal ~

Any [portable dial](#) with a means of allowing it to work at, or be adjusted for, any [latitude](#). Note: sometimes the range of usage is limited to one [hemisphere](#). The term is also sometimes applied, with qualifications, to dials which operate over a more limited range of latitudes, e.g. dials with, say, 30°- 60°N scales.

universal equatorial ring ~ (or – equinoctial –)

A portable dial which looks similar to a folding version of an [armillary dial](#), but with a movable suspension point to provide latitude adjustment. A stylised version of the hour ring and [gnomon](#) forms the BSS logo. In some versions, an [aperture](#) gnomon mounted on the central axis is used, the position of the aperture being adjusted to suit the [sun's declination](#). This form is self-orienting. Large well-made versions are accurate and valuable.

vertical ~

Any dial in which the [dial plate](#) is vertical.

window ~

: (or projecting ~) a ~ in which the [hour lines](#) are marked on a window in such a way that their shadows fall across a single reading point inside the room. The lines, as drawn on the window, form an inverted, mirror-imaged [vertical dial](#). This form is related to [stained glass](#) and [mirror \(or ceiling\) ~](#).

– End of Dial types –

dialling scales: ruler-like (or rule-like) scales designed to help in the geometrical layout of dial. Their non-linear scales are effectively analogue computers for solving dialling equations. Standard scales, following George Serle's original version of 1657, and themselves developed from Samuel Foster's 1638 work, have separate scales for : hours, latitude (prime) and latitude (meridian).
dial plane: the plane in which the dial plate, and the hour indicators, lie.
dial plate (or ~ face): the physical plate on which the [hour lines](#) and [furniture](#) lie. It (usually) supports the [gnomon](#).
diffraction grating: a plate with a set of closely spaced slits (usually parallel and equi-distant) which disperses incoming light into its constituent wavelengths (i.e. colours). The surface of a CD acts as a circular reflection diffraction grating.

dioptra

{dioptra}: a form of [alidade](#), used as the index of a volvelle (and also sometimes of a [quadrant](#) or an [astrolabe](#)), rotating against an angle scale.

dip

Below the true or astronomical horizon. It is given by:

dip (arc-minutes) = 1.811 x v height (metres).

dip

With the date. See [Appendix IX](#) for values. It is measured with an [inclinometer](#).

dipleidoscope

From the Greek words for “double image viewer”. Devised by James Bloxham and patented by Edward Dent in 1843. It is an instrument for observing the [transit](#) of the Sun to an accuracy of a few seconds. Essentially, it comprises a hollow equilateral prism, with the front, semi-reflecting face facing south and parallel to the polar axis. At noon, the reflection of the Sun from this surface exactly coincides with a second image doubly reflected from the other two faces.

diptych

Literally, two leaves or pages. See [dial types](#), [diptych](#) .

diurnal

Daily, or occupying one day. Can also mean of the daytime (as opposed to nocturnal: of the nighttime).

domifying circles

On a [horizontal dial](#), these lines all lie parallel to the [noon line](#). See [Appendix V](#).

Dominical cycle: a letter-cycle originating in the Roman period, when each day of the year was allocated

the letters A,B,C,D,E,F and G in a repeating sequence. In a given year, every weekday (e.g. Monday) has the same letter, and the cycle repeats with the 28-year Julian [leapyear](#) cycle. The Dominical letter (for Sundays) is often found on [portable dials](#), and is used with the [Golden Number](#) to find [Easter](#).

dusk

The evening [twilight](#) period.

The BSS Sundial Glossary

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E

earthshine: the illumination resulting from sunlight reflected from the Earth, particularly when providing low-level illumination of the “dark” portion of the Moon.

East

The point on the horizon 90° (measured clockwise) from the North. The Sun appears to rise from the East point on the [equinoxes](#).

Easter

The requirement to set the date of this Christian festival drove much of the early astronomy and calendar reforms. The standard astronomical algorithm for the date is now “the first Sunday after the full moon ([paschal moon](#)) that occurs upon, or next after, the [vernal equinox](#)”. However, because the rules were set by the Christian clergy before the dates of the equinoxes could be defined accurately, the vernal equinox for this calculation is always taken as 21 March. See [Meeus](#) or [Duncan](#) in Sources for a full algorithm. The extreme dates of Easter are 22 March and 25 April

eccentricity (of the Earth’s orbit): [**e_c** , **EC**] a measure of the relative sizes of the major and minor axes of the Earth’s elliptical [orbit](#). $e_c = 0.01671\dots$ in the year 2000 and is slowly decreasing. $e_c = 0$ would imply a circular orbit. The earliest accurate value was found by John Flamsteed, the first Astronomer Royal, in about 1700 (most of his results were only published after his death in 1707).

eclipse(of the Moon or the Sun): the phenomenon which occurs when the Earth (or at least the observer’s location), Sun and Moon lie on a straight line. If the Moon lies in the [ecliptic plane](#) between the Sun and the Earth, a solar eclipse occurs (either full, partial or annular, depending on the relative distances). If the Earth lies between the Sun and the Moon (i.e. at a full moon) a lunar eclipse is seen.

ecliptic (plane)

The plane that the Earth’s [orbit](#) traces during a year. The orbits of the Moon and the planets are also close to this plane. It is the plane in which [eclipses](#) occur since, by definition, the Sun is always on the ecliptic. It is a [great circle](#) on the [celestial sphere](#).

ecliptic latitude

[**d**, **ELAT**] is the position of a body on the [celestial sphere](#), measured along the [great circle](#) from the [ecliptic](#). Positive to the north, negative to the south, range -90° to $+90^\circ$. It is part of the [ecliptic co-ordinate system](#).

ecliptic longitude

[ϵ , ELON] is the position of a body on the [celestial sphere](#) measured around the ecliptic from the [vernal equinox](#) positive to the east. Range 0° to 360°. It is part of the [ecliptic co-ordinate system](#).

elevation

See [altitude](#).

ellipse

A [conic section](#) and the path the Earth follows during a year (neglecting only the small perturbations caused by the moon and the other planets). It is defined by two foci, and by a major and a minor axis. A circle is a special case of an ellipse with the two foci coincident, and the major and minor axes equalling the diameter. The elongation of an ellipse is characterised by its [eccentricity](#). Also, the outline shape of an [analemmatic dial](#).

ellipsoid

A closed geometric surface obtained by rotating an [ellipse](#) around its major or minor axis.

elongation (of the Moon): : the angle of the Moon relative to the Sun, as viewed from an observer on the Earth. The term may also be applied to the planets. An elongation of 180° implies a full Moon.

epact (number): the number of days past the full moon on the 1st January of any year in a 19-year [metonic cycle](#) (the period before the Sun and the Moon are again in the same relative positions in the constellations). Epact tables are found on old dials, particularly [portable](#) ones, in conjunction with lunar [volvelles](#) and [calendars](#). In conjunction with an [almanac](#), they can be used to predict the date of [Easter](#).

ephemeris

A table of predicted positions of celestial objects as a function of time. Astronomical [almanacs](#) invariably include an ephemeris for the Sun.

ephemeris second

An obsolete definition of a second used between 1955 and 1965, based on the Earth's speed of rotation. Now replaced – see [second \(of time\)](#).

epicycle: a small circle whose centre moves around the circumference of a larger one. It was proposed as the shape of the orbit of some of the planets by [Ptolemy](#).

epoch

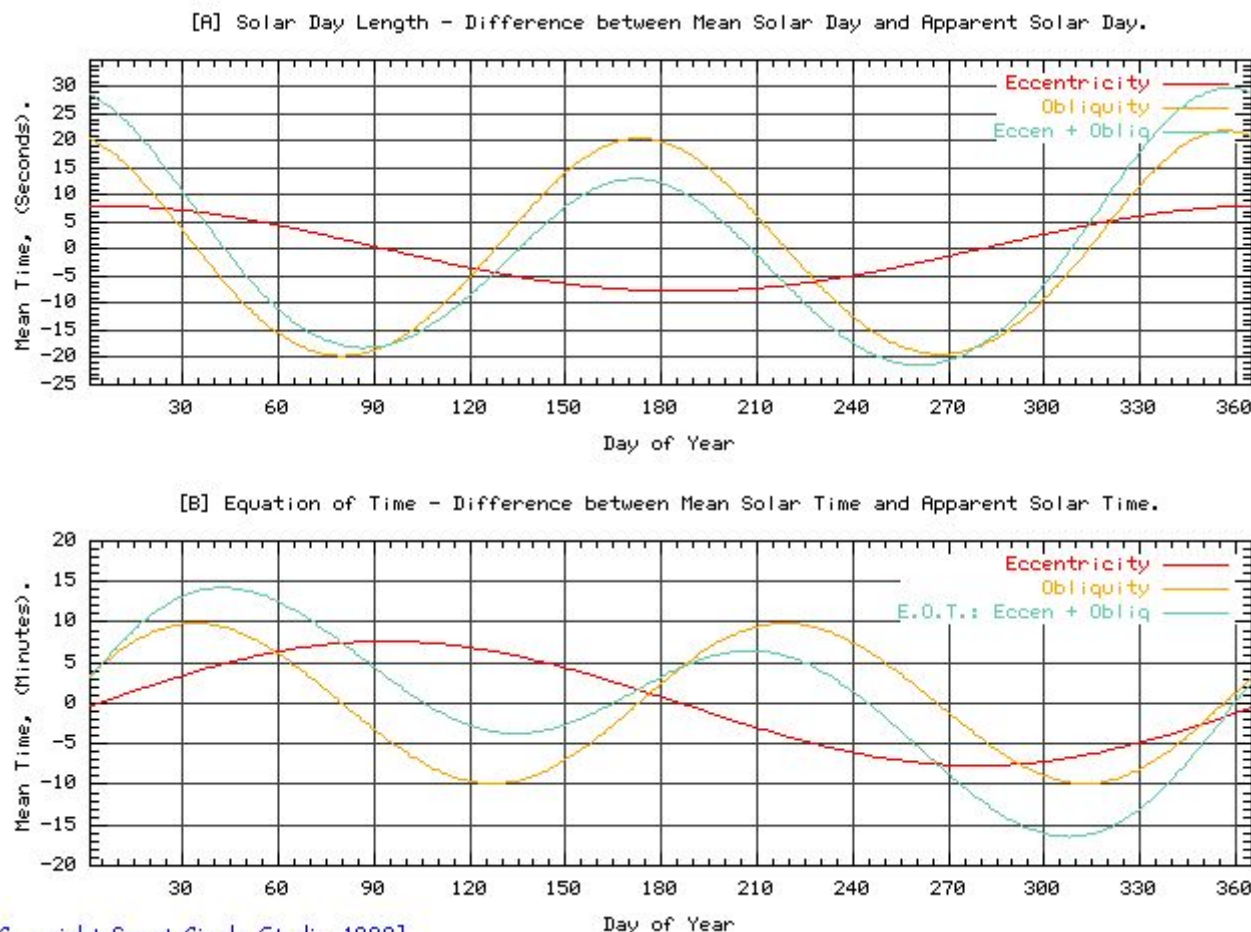
A particular fixed instant used as a reference point on a time scale for astronomical calculations, e.g. J2000.0 or noon 1 Jan 2000 (2451545.0 JD). The word epoch also occurs on some dials, for example, in tables for calculating Easter.

Equation of Time

[E, EoT] the time difference between [Local Apparent Time](#) (apparent solar time) and [mean solar time](#) at the same location. Its value varies between extremes of about +14 minutes in February and –16 minutes in October. It arises because of the elliptical [orbit](#) of the Earth, and the tilt of the Earth's [axis](#) to the [ecliptic](#). The preferred usage by diallists is:

$$\text{mean solar time} = \text{apparent solar time} + \text{EoT}$$

but this sign convention is by no means universal and the opposite sign is used in modern almanacs. Irrespective of the sign convention adopted, sundials will always appear slow compared to mean time in February, and fast in October/November. See [Equations](#).



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Figure 5. The Equation of Time and its components.

EoT varies continuously, but is usually tabulated for [noon](#) each day at a particular location. Hence values for America (e.g. as printed in the NASS Compendium) can be a few seconds different from those in Europe. The noon EoT on a particular day varies slightly over the [leap year](#) cycles (4, 100, 400 years), and more significantly over millennia.

The first published tabulation of the EoT was by Christiaan Huygens in 1665, but the knowledge of its existence probably goes back to [Ptolemy](#). The first Astronomer Royal, John Flamsteed (1646-1719) produced the first English tables in 1672.

EoT

Can also be expressed as an equivalent [hour angle](#)

equant point [E_a,EOTA]

A point in [Ptolemy's](#) model of the solar system around which the Sun and the planets rotate.

equator

The [great circle](#) of the Earth (or other celestial body) which is equidistant from the [poles](#). It has, by definition, a [latitude](#) of 0°.

equatorial mount

A mount for an instrument (e.g. a telescope) which has one axis parallel to the polar [axis](#) and another at 90° to this (the declination axis).

The [diurnal](#) motion of a celestial body can be followed by rotation about the polar axis alone. A polar-pointing gnomon could act as the axle for such a mount.

equatorial plane

The plane through the Earth defined by the [equator](#).

equinoctial plane

The plane of the [equator](#) extended to the [celestial sphere](#), i.e. defined by the [celestial equator](#).

equinoctial line (on a dial)

Is the line followed by the shadow of a [nodus](#) on the [equinoxes](#). For a plane dial, it is a straight line perpendicular to the [sub-style](#).

equinoxes

Literally “equal nights” i.e. equal amounts of daylight and night-time. Astronomically, the points where the plane of the [ecliptic](#) cuts the [celestial equator](#), or the moments when the Sun is at these positions. The vernal ~, around 20-21 March, is also called the **First point of Aries** and represents the zero of [ecliptic longitude](#) and [right ascension](#). Thus the Sun has an ecliptic longitude of 0° or 180° at the ~. Day numbers of the Earth's orbit are usually counted from this point. The autumnal equinox is around 22-23 September, and has a right ascension of 12h. The Sun's [declination](#) at the equinoxes is 0°.

See [Figure 1](#).

establishment (of a port): the interval between the time of the moon passing the [meridian](#) and high tide at the port. It is indicated on some [equiangular dials](#) which can indicate the times of the tides ([tidal dials](#)).

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F

fiducial line

(or ~ edge): (pron. fid-oo-shal) the edge of an index plate or pointer against which a scale is read.

filem

An old term for a plumbline, particularly on a [card dial](#), to show the vertical.

First point of Aries

See the definition for [equinoxes](#). Note that, because of the [precession](#) of the equinoxes, this point currently lies in the constellation of Pisces.

fleur-de-lis

{fleur-de-lys}: an heraldic symbol of a stylised Madonna Lily, composed of three petals bound together near their bases. Often used on dials to denote the half-hour lines.

furniture

All features on a [dial plate](#) other than the [hour lines](#) and their numerals are referred to as dial ~. This may include [declination lines](#), [compass rose](#), [EoT](#) graphs or tables, [mottoes](#) etc. Other common furniture includes: date, maker's and/or benefactor's name, coats of arms, and [latitude](#) and (rarer) [longitude](#). See [Figure 1](#).

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G

Geographic Position (GP)

: the point on the Earth's surface directly beneath a celestial body (i.e. where a line to the body from the centre of the Earth intersects the surface).

geoid

The Earth's shape, formed by the mean sea level and its supposed extension under the land masses. It cannot sensibly be represented mathematically, and is often approximated by one of many ellipsoids. Those most likely to be encountered are the Airy 1836 ellipsoid, used to define [Ordnance Survey](#) maps, and the WGS 84 ellipsoid, used in the [GPS](#) system.

globe

A spherical chart of the Earth. Note that although the Earth's [geoid](#) is actually a flattened ellipsoid (i.e. slightly melon-shaped with an equatorial radius of 6378 km, and a polar radius of 6357 km) the spherical representation is used for all dialling activities with the exception, for example, of the model used by the [GPS](#) system.

gnomon

Gnomon: the physical structure of a sundial which casts the shadow. See [Figure 1](#).

Hence **gnomonics**: the science of sundialling and **gnomonist** (seldom used): a person who practices gnomonics.

Golden Number: a number sequence (1-19) used to describe the year number in the [metonic cycle](#). It was

used, together with the [Dominical letters](#), to find [Easter](#), and is often found on [portable dials](#).

grade

[grad] a unit of angular measurement, equal to 1/100th of a right angle, or

p

/200 radians. Used particularly in France in the 18th and 19th centuries.

great circle

A circle on the surface of a sphere whose diameter is equal to the diameter of that sphere. Thus the circle has the same centre as the sphere. The shortest route between two points on the surface of a (solid) sphere lies on the circumference of the great circle connecting them.

GPS (Global Positioning System)

A system of polar-orbiting satellites, run by the US Dept. of Defense, which allows hand-held radio receivers to provide accurate 3-D location information anywhere on (or near) the Earth's surface. It also provides a highly accurate clock, based on [UTC](#). The system uses the WGS84 [co-ordinate system](#) and description of the Earth's [geoid](#).

grazing incidence: a term used to describe illumination in which the [rays](#) are parallel to the receiving surface. The shadow of a point above the surface falls at infinity.

green flash

An atmospheric phenomenon occasionally observed during the final phase of [sunset](#), when the upper [limb](#) of the Sun shows as a green flash due to the complex wavelength-dependence of [atmospheric refraction](#).

Greenwich Mean Time (GMT

): see [GMT](#), *time (types of)*

Greenwich Meridian

The line of [longitude](#) (or half a [great circle](#)) passing through the centre of the Airy transit circle at the old Royal Greenwich Observatory in London, and which defines the origin of Longitude ($^{\circ}$ = 0°). It is now designated the [Prime Meridian](#). Note: prior to 1884, there was no single fixed prime meridian, and hence early sundials sometimes refer to different origins, notably Paris.

Gregorian calendar

The calendar first introduced by Pope Gregory XIII in 1582 AD and now the accepted calendar throughout the vast majority of the world. It introduced the modern system of [leap years](#) which results in an error of only 3 days in 10,000 years. Note that adoption of this calendar throughout Europe took an extended period. Its introduction in Britain in [1752](#) produced a step change of 11 days which can be seen in the difference between [EoT](#) tables on dials earlier than this and those on later ones.

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H

halcyon days

: (pron. hal-ce-on) originally, 14 days about the winter solstice. Now taken as simply calm, peaceful.

Hallomas: All Saints' day on 1st of November. It is one of the [cross-quarter days](#).

hectemoros angle

[hec] (pron. hec-tem-or-os) the angle from the western horizon to the sun's position, measured around the *hectemoros* circle. Part of the [ptolemaic co-ordinate](#) system, and related to the [seasonal hours](#).

hectemoros circle

The [great circle](#) that passes through the E-W points on the [horizon](#) and through the sun's position.

heliacal rising

The instant of the earliest visibility of a star in the East at dawn. The heliacal rising of the star [Sirius](#) was used by the ancient Egyptians to predict the coming of the annual Nile flood. Since their year had 365 days, this occurrence had a variable date.

height (of a style)

See [style height](#).

heliocentric

An adjective to describe a model of the solar system which places a stationary Sun in the centre, with the planets revolving around it.

heliograph

Has two distinct meanings: (i) a device for transmitting morse signals over extended distances by using an accurately aligned mirror to send flashes of sunlight to the receiving station. For long messages, the ~ has a mechanism for tracking the sun's motion. (ii) an astronomical instrument for studying sunspots, as built by George Airy at Kew in 1873.

heliometer

A telescope which produces two images of the Sun which can be manipulated to determine its angular size accurately. Invented in 1754 by John Dollond of London, it is also used to measure angular distances between stars.

heliostat

A scientific instrument which holds an image of the Sun stationary, allowing extended observation (e.g. for solar spectrometry).

hemisphere (northern ~ and southern ~)

One half of the Earth's globe, either north of or south of the [equator](#). Note that a sundial at a particular [latitude](#) in one hemisphere must be reversed for use at the reciprocal latitude in the other hemisphere.

horarius circle

The [great circle](#) that passes through the N-S points on the [horizon](#) and through the sun's position.

horarius angle

[hor] the angle from the southern horizon to the sun's position, measured around the *horarius* circle. One of the [ptolemaic co-ordinates](#).

horizon

The line of intersection between the sky and the Earth. For normal astronomical purposes, the observer's horizon is taken to be the [great circle](#) on the [celestial sphere](#) on which every point is 90° from the observer's [zenith](#). The **observed horizon** (accounting for the curve of the earth and the height of the observer above its surface, but excluding [refraction](#)) is below the astronomical horizon by an angle called the [dip](#). This can have a significant affect on the times of [sunrise/sunset](#).

horologia

The collective Latin name for dials, water-clocks and sand-glasses, used in the Middle Ages.

horologium: a name used to describe medieval manuscripts listing shadow lengths, deriving from the Latin name for timepieces. Modern versions have also been produced. In modern astronomy, it is also the name of a faint southern constellation ("the Clock").

hour

Usually means 1/24th of a [mean solar day](#), unless otherwise stated. Scientifically, it is defined as 3600 standard [seconds](#). See [Hour \(types of\)](#) for other definitions. The word derives from the Latin "hora", which was synonymous with prayer.

hour angle

[h, HA] the angle corresponding to the sun's position around its daily (apparent) [orbit](#). Measured westward from local [noon](#), it increases at a rate of 15° per hour. Thus 3pm (Local Apparent Time) is 45° and 9 am is -45°.

hour circle

A [great circle](#) on the [celestial sphere](#) that passes through the [celestial poles](#). It is orthogonal to the [celestial equator](#).

hour line

The line on a [dial plate](#) indicating the shadow position at a particular time (includes fractional as well as whole hours). See [Figure 1](#).

hour line angle

[X, HLA] the angle that an [hour line](#) on a [dial plate](#) makes with the [noon line](#). The angle increases with time (i.e. positive for the p.m. hours). Thus, for a horizontal dial, the angle increases clockwise (hence the origin of the term) whereas for a vertical south-facing dial, it increases counter-clockwise. Beware, this convention is not used by all authors, and some define the angle with respect to the [sub-style](#) line.

hour point

A point on the [dial plane](#) indicating the crossing of the [gnomon](#)'s shadow at a particular time. Hour points replace [hour lines](#) on dials where the shadow edge does not pass through the dial [centre](#).

hour plane

The plane which, at any instant, contains the sun, the observer and the [N celestial pole](#). The [style](#) and the appropriate [hour line](#) lie in the hour plane.

Hours (types of):

antique ~: same as [unequal hours](#) or seasonal hours. Babylonian ~: number of hours elapsed since [sunrise](#), with 24 equal hours per day. The origin of the term is unclear, but may be related to the fact that the ancient Babylonians originated the base-60 counting system for angles etc. They are sometimes written as "horae ab ortu solis" or H. AB ORT." on dials. See [Equations](#) for conversion from equal hours to Babylonian hours. biblical ~: same as [unequal hours](#) or seasonal hours. Bohemian ~: same as [Italian ~](#). **Canonical ~**

The seven times of the day (as opposed to time periods) used to define the services or divine offices in the medieval church. These offices were based on the sixth century Rule of St. Benedict. See [Appendix IV](#) for details.

An alternative definition of the term canonical hours, sometimes applied to lines on early Italian dials, is the system of putting equi-angular hour lines around the base of a horizontal gnomon on a vertical south dial.

common ~

The standard 2 x 12 equal hour system, also called German or French ~. In Latin "horae communes", they are often labelled "kleine uhr" (small hours) on [Nuremberg dials](#).

decimal ~

: an hour system with ten equal hours per day (as sometimes used by the Chinese and ancient Egyptians, and during the French Revolution).

equal ~

Any hour system where the length of an hour is independent of the date, and the same during [daytime](#) and night-time.

French ~

An early name for the equal hour system with 2 x 12 hours per day, beginning at midday and midnight. Sometimes written “Oltromontane”.

French revolution ~

The equal hours according to [French Revolution time](#).

Great ~:

a term for any of the [unequal hour](#) systems. Often labelled “grosse uhr” on [Nuremberg dials](#).

Greek ~

Same as [Babylonian ~](#).

Italian ~

Are often used synonymously in modern works but there is some evidence in older works that Italian hours were counted from 30 minutes after sunset. See [Equations](#) for conversion from equal hours to Italian hours.

modern ~

The equal hours as used in modern time systems. They may occasionally be referred to as common, European, French, German or vulgar hours.

Nuremberg ~

A hybrid [equal hour](#) system. The daylight hours were measured using the [Babylonian ~](#) system, starting with 1 at sunrise, while the night hours started with 1 at sunset and used the [Italian ~](#) system. In Latin, “horae norimbergenses”.

octaval ~

A time system with the period of daylight divided into eight hours. Probably introduced by the Romans, circa 250AD. See [Appendix III](#) for the names of the daylight periods.

planetary ~

A planetary hour is the time needed for 15° of the [celestial equator](#) to rise above the [horizon](#), counting from [sunrise](#). As there is always 180° of the celestial equator above the horizon, there are 12 planetary hours from sunrise to sunset but they are unequal not only from day to day but also from hour to hour. Note: this definition is based on the writings of Sacrobosco, but some authors use planetary hours simply as another form of seasonal hours, with the hours associated with the “planets”. See [Appendix VIII](#) for the symbols of the planets and this association. The [Zonwvlak](#) program uses the definition of the German scholar Joseph Drecker (1925) who defines a planetary hour as the time for 15° of the [ecliptic](#) to rise above the horizon (counting from sunrise) and are hence very irregular.

seasonal ~

A form of [unequal hours](#), usually with 12 daytime and 12 night-time hours. Named from the fact that the length of an hour varies with the [seasons](#).

temporal ~

or **temporary ~**: an [unequal](#) hour system with 12 hours from sunrise to sunset, and 12 hours (of a different duration) from sunset to sunrise.

unequal ~

An hour system where the duration of an hour depends on the date and is different from day-time to night (except at the [equinoxes](#)). The number of hours during day-time is usually 12, but may be 8 and just possibly 10 (e.g. on some mass dials). Counting of the daytime hours begins at sunrise.

Welsch

~: i.e. foreign. Same as [Italian ~](#).

End of Hours (types of)

house: (astrological) a segment of the [celestial sphere](#). Several methods of dividing the sphere into segments exist, the most common of which produce the signs of the [zodiac](#), and the [Regiomontanus houses](#).hyperbola: a [conic section](#), its most common use in dialling is the shape of the [declination lines](#) on a dial.

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I

Imbolic: an ancient Celtic festival held on the 2st of February, celebrating fertility. It is one of the [cross-quarter days](#)

inclination

[*i*, I] the angle between the back of the [dial plane](#) and the horizontal for [inclining](#) or [reclining](#) dials. Equivalently, it is the angle between the [zenith](#) and the positive z [co-ordinate](#) of the dial. $i = 0^\circ$ implies a [horizontal](#) dial. For an inclining dial, $0 < i < f$ (the latitude of the place). For a reclining dial leaning away from the observer, $i < 90^\circ$; whilst $i > 90^\circ$ implies a proclining dial leaning forward towards the observer. Beware: this convention is not followed by all authors.

inclinometer

An instrument for measuring the [inclination](#) or slope of a surface. Two types are common: simple devices with a plumb-line hanging across a protractor, or precision ones where a sensitive spirit level is moved to the horizontal position against an accurate scale. Note: the term inclinometer is also used to describe an instrument – also called a **dip circle** – for measuring the vertical component of the Earth's magnetic field.

index

Besides its normal meaning of an alphabetical list, an ~ is a pointer on a scientific instrument, indicating a point on a graduated scale. The **index arm** of a sextant is the movable arm carrying the index mirror and the [fiducial line](#).

inferior

Refers to an event on the [celestial sphere](#) below the [horizon](#). Opposite of [superior](#).

inhiraf

The angle which the [qibla line](#) makes with the north ray of the meridian at any location.

International Date Line

The line from the N to S [poles](#), approximately following the 180° line of [longitude](#), through which the date alters by one day (positively if travelling from W to E). Variations from the 180° meridian are made to avoid political and geographic boundaries.

Islamic prayer lines

The lines on Islamic dials where the shadow of the [nodus](#) falls at the times when Muslims must pray. The times of the three most common lines are determined by a linear relationship to the [noonshadow](#) length of a vertical [gnomon](#):

zuhr

Noon shadow + 0.25 x gnomon height

asr-awwal

Noon shadow + gnomon height

asr-tânî

Noon shadow + 2 x gnomon height

isogonals

Lines of equal [magnetic deviation](#) plotted on some navigational charts

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J

Jaipur

A famous early 18th century solar astronomical centre in India, constructed by the Maharaja Jai Singh around 1724. It includes many monumental sundials, including a famous [equatorial](#) one with a gnomon 27 metres high.

Julian calendar

The [calendar](#) system introduced by Emperor Julius Caesar and devised by the Greek philosopher (and court astronomer of Egypt) Sosigenes. Widely used from 45BC to 1582AD. By this date, it was in error (compared to the Earth's orbit) by 10 days due to the imperfect use of [leap years](#) (i.e. it assumed the length of a year was 365.25 days).

Julian Day

That Scaliger named the system after his father.

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K

kamál

An early Arabic navigational instrument for determining the Sun's [altitude](#) by means of a transom and a knotted cord.

Kepler's Laws

(of planetary motion): three laws which describe the motion of the planets around the Sun, after Johannes Kepler (1571-1630). They are:

- Planets travel in elliptical (rather than circular or epicyclic) orbits, with the Sun at one of the foci.
- The line joining the Sun and the planet sweeps out equal areas of space in equal time intervals (so that the planet moves faster when it is nearer the Sun, and establishing the Sun as the main controller of the planets)
- The link between the size of the planet's orbit and its period of rotation is described mathematically. *klimata*: (pron. clim-arta) part of an [astrolabe](#), it is a disk rotating on the [mater](#) with the north [celestial pole](#) in the centre and showing [almucantar](#) lines for the design location. After the Ancient Greek meaning "angle of the Sun's rays", and hence the modern word "climate".

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L

Lambert's circles

: circles of construction used when drawing sets of nested [ellipses](#) to represent [analemmatic dials](#) for different [latitudes](#), these dials using a common scale for the (vertical) [gnomon](#) position. Such sets of dials are particularly useful for a [solar compass](#), e.g. the Cole sun compass used in N. Africa during the Second World War. After the mathematician Lambert (b. 1728, Alsace).

Lammas (or Lammas Day): one of the [cross-quarter days](#). It is on 1st August, and was formerly observed as the harvest festival.

latitude

[f

, **PHI, Lat]** Note: avoid LAT, since it implies local apparent time. It is the angular position of a place north or south of the [equator](#). Positive values in the Northern [hemisphere](#), negative in the South (i.e., the South Pole has

f

= -90°). Part of the [geographic co-ordinate system](#), the term comes from the Greek “latus” (breadth).

leap second

An extra [second](#) inserted into [UTC](#) at the end of some years between 24:00:00 Dec 31 and 00:00:00 Jan 1 to ensure that UTC remains in step with the Earth's [diurnal](#) rotation. It may also be added at the end of June. The addition is not predictable as it depends on many factors, such as the increased atmospheric drag on the Earth in El Niño years. The actual addition is performed by the Bureau International des Poids et Mesures near Paris. Leap seconds are gradually becoming more common as the rate of the Earth's rotation slows due to energy dissipation by the tides.

leap year

Years in which an extra day (February 29) is introduced so that the ([Gregorian](#)) calendar keeps step with the Earth's [orbit](#). The rule for leap years is that a year is a leap year if and only if the year number: is divisible by 4, except years divisible by 100 which are not leap years unless they are also divisible by 400. This corresponds to the length of the year being 365.2425 [mean solar days](#). This can be compared to the 365.25 days in the earlier [Julian calendar](#). (The Julian leap year doubled February 24.) The leap year system causes the [EoT](#) (and [Sun's declination](#)) on a particular day of the year to exhibit a small periodic variation.

lemniscate

The term used in Latin countries for the [analemma](#). From lemniscus, meaning ribbon. In English, the ~ is a mathematical curve which is similar to a spiral and is sometimes used in road design; it also looks similar to one lobe of the analemma.

libration (of the Moon)

The periodic oscillation of the Moon from 'side to side' (and 'up and down') which allows an observer on the Earth to see somewhat more than half its surface.

limation

Had the meaning 'filing or polishing'.

limb

Part of an [astrolabe](#), it is the circular ring with a scale of hours and degrees. Its first recorded English use was in 1593.

limb

. The term **limb darkening** indicates that the disk of the Sun does not have uniform brightness but is dimmer around the "edges" due to increased optical absorption by the [photosphere](#).

local apparent time

[**L.A.T.**] solar time see [LAT \(types of\)](#). Hence **local apparent noon**, at the Sun's [superior transit](#).

local hour angle

. Beware, this convention is not universal.

lodestone

A naturally occurring oxide of iron, mounted with two iron poles in a non-magnetic frame. Used for magnetising compass needles, small ones were made specially for [portable dials](#).

longest day: a term in common parlance, defined as the day of the year with the greatest (astronomical) [sunrise](#) to sunset period. It is normally used synonymously with the summer [solstice](#) although, strictly, it can vary by a day depending on the exact time of the solstice and the relationship between the rate of change of the [EoT](#) and that of the local sunset/sunrise.

longitude

[?

, λ , **LON**] the angular location of a place on the Earth's surface measured east or west of the [Prime meridian](#) though Greenwich. Longitudes W are positive, E are negative. Part of the [geographic co-ordinate system](#), the term comes from the Greek "longus" (length). See also [Prime Meridian](#).

Longitude Act

A 1715 act of the British parliament which established a Board of Longitude to manage a prize of £20,000 for a practical method of finding longitude at sea.

longitude correction

The correction required to [local apparent time](#) to translate it to the L.A.T. for the central meridian of that [time zone](#). The correction is +4.0 minutes for every 1° longitude W of the time zone [meridian](#) (and −4.0 minutes for E). Sometimes, this correction is built into the [hour lines](#) by calculating the local [hour angle](#) for times at the zone meridian.

lunar angle

The difference between the [right ascensions](#) of the Sun and the Moon. On a standard sundial used as a [moon dial](#), the L.A.T. equals the time shown by the lunar shadow plus the lunar angle expressed in hours.

lunation

The time interval between successive New Moons. The mean interval is 29 days 12 hours 44 minutes 3 seconds (the [synodic month](#)) but, because of the perturbing action of the sun, the difference between the shortest and longest lunations in the 20th century is 5 hours 19 minutes.

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M

Mach bands

: (pron. mak) subjective light and dark bands which an observer sees when looking at a black-white edge. They are produced by the brain's visual processing (i.e. they are not real) and have the effect of sharpening up edges. First described by the German physicist Ernst Mach (1838-1916).

magnetic variation

{magnetic declination, magnetic deviation}: Note, the use of the term magnetic declination is best avoided because of confusion with the other types of declination. It is the angle between the true N [pole](#) and the magnetic N pole. At present in the UK, the magnetic pole is very approximately 3° W of true north, and decreasing by about 12' annually. See [Appendix IX](#) for more detailed and historical values. There can be large local variations to the general values, some of which can be found mapped on navigational charts. The use of a magnetic compass for aligning a permanent dial is not recommended, even if due corrections are made, as the presence of steel or magnetic rocks will cause very local variations.

manaeus

The circle of months which formed part of the ancient [orthographic](#) spherical projection used by late Middle age diallists. It establishes the [sun's declination](#).

maquette

A sculptor's small preliminary model. The term is used to describe small mock-ups of three-dimensional dials.

Martinmas: St Martin's day, on 11th November. It is one of the [cross-quarter days](#).

mass dial

See Dial types ([mass dial](#)).

mater

The heavy disk which forms the base of an [astrolabe](#).

mean solar day

The time between successive [transits](#) of the fictitious mean Sun (i.e. an imaginary sun which appears to circle around the [celestial equator](#) at a constant rate equal to the average rate of the Earth's real rotation). The basis of [civil](#) time keeping.

mean time

See [Time \(types of\)](#).

mean local time

.

Mercator projection

The most common projection used to produce a 2-D map of the [globe](#). Developed by Gerardus Mercator in Belgium, 1586. It has straight meridians and parallels of latitude that intersect them at right angles. Scale is true at the equator or at two standard parallels equidistant from the equator.

The **Transverse Mercator** projection is obtained by projecting the sphere onto an enclosing cylinder tangent to a central meridian. This is the projection used for [Ordnance Survey](#) maps of the UK.

merkheth

A [transit](#) instrument from ancient Egypt, consisting of a horizontal “L” shaped stone with a plumb-bob supported from the short vertical arm. It was used in conjunction with a [bay](#).

meridian

The [great circle](#) (or, more usually, half of a great circle) passing through the N and S [poles](#). The same as a line of [longitude](#). The term is sometimes used to mean the meridian line passing through the observer’s location, or its representation on the [dial face](#).

meridional

South-facing (e.g. a [direct-south dial](#)). In more general usage, it generally means of, or from, the south.

meridian line: see [Dial Types \(noon line\)](#) for the lines inscribed in the floors of Renaissance cathedrals

, etc.

metonic cycle

A cycle of 19 years (or 235 lunar months) over which the Sun and the Moon return to the same relative positions amongst the constellations. It was discovered by the Greek astronomer Meton c.433 BC and determines the [epact](#) number and the [Golden Number](#). Actually, the moon runs 1½ hours slow over this period, or one day over 312.7 years. This fact has to be included in the calculations for [Easter](#).

midnight

Strictly, the time when the Sun achieves its most negative [altitude](#) (or, equivalently, when its [azimuth](#) is $\pm 180^\circ$). More loosely defined as half-way between [sunset](#) and [sunrise](#) or, with even less accuracy, 12 hours after local [noon](#).

midsummer, midwinter (~ day)

The same as summer or winter [solstice](#). Note that **Midsummer** (with capital M) is a legal term for the [Quarter Day](#) on June 24.

mil

Unit of angular measurement used in some military equipment, e.g. rangefinders, theodolites. 6400 mils = 360°. Beware possible confusion with use as a linear measurement of 1/1000 inch used by engineers (particularly in the USA).

mileways

An obsolete term for an [hour angle](#) of 5°, equivalent to 20 minutes of time. So called because this is the approximate time that it takes to walk one mile.

minute of arc

See [arc minute](#).

minute

Is now defined as 60 [seconds](#). Historically, the definition was 1/60th hour, where the [hour](#) was derived from the rotational period of the Earth.

month

An interval of time related to one revolution of the Moon around the Earth (a “moonth”). The calendar month derives from the **synodic month** (full-moon to full-moon) which averages 29.53 days. The **anomalistic month** ([perigee](#) to perigee) averages 27.53 days.

Moon

The natural satellite of the Earth. It has a mean distance from the Earth of 384.4×10^3 km and a semi-diameter at mean distance of 15' 33". The inclination of its orbit to the ecliptic is 5° 8' 43". Note: “moon”, without an initial capital letter, is sometimes used to refer to moons of planets other than the Earth.

moondial

See [Dials \(types of\)](#).

moonlight

Rays of light which reach the observer directly from the Moon, having originally been [sunlight](#) reflected by the Moon's surface. There is usually sufficient light to cast a shadow only between the 1st and 3rd quarters of the Moon. Since the angular size of the Moon is approximately the same as that of the sun, the ratio of [umbra](#) to [penumbra](#) of a moon shadow is also the same as for a sun shadow.

motto

A sentence, phrase or verse inscribed on a dial expressing an appropriate sentiment. Mottoes started appearing on dials in the late 16th century but were particularly popular in the 19th century.

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N

nadir

: the point on the [celestial sphere](#) that is diametrically opposite the observer's [zenith](#).

nautical mile

A distance (6080 feet or 1853 metres) determined as 1 arc-minute of [longitude](#) at the [equator](#).

night

(or **night-time**): the period of darkness between [sunset](#) and [sunrise](#).

nocturnal

. These are known as the Little Dipper and Big Dipper, respectively, in the USA. Most nocturnals have inscriptions “GB” and “LB” on their scales. The term ~ can also be used as an adjective, meaning “of the night”.

nodus

A point which casts a shadow to indicate the time and/or date on a [dial face](#). It may take the form of a small sphere or a notch on a polar-pointing [gnomon](#), or it may be the tip of a gnomon with an arbitrary (usually horizontal or vertical) orientation. See [Figure 1](#).

nodus height

[N, NH] the height (distance) of a [nodus](#) perpendicular to the [dial plane](#). It is also the same as a vertical style height.

nomogram (

sometimes **nomograph**): a system of graphs showing relationships between three or more variables. From the Greek “nomos” (law).

nonius

A device similar to a [vernier](#) for interpolating readings on an angular scale, but using a large number of concentric scales rather than a single movable one. Named after the 16th century Portuguese mathematician Pedro Nões.

noon

The time of the sun's [transit](#) each day. Equivalently, the time that the Sun reaches its largest [altitude](#) for that day. Note that noon is specific to the observer's location, unlike 12:00 o'clock with which it is often confused.

The word ~ originates from the Latin 'nonus' or ninth, indicating the ninth hour of the day counting from sunrise. By 1420 it meant the hour or ecclesiastical office of Nones, so noon gradually became associated with the beginning of this office.

noon cross

A cross shape often seen instead of XII on the [noon line](#) of dials. It can have many forms, many of which look like an Iron or Maltese cross. The nearest heraldic term is the [cross patty](#).

noon gap

The gap in the hour scale of a dial to account for the finite thickness of the [gnomon](#). It is positioned on the dial plate where the Sun is in the same plane as the gnomon, i.e. at [noon](#) for horizontal or direct S dials. A gnomon gap is occasionally seen on the [sub-style](#) of a [declining](#) dial. See [Figure 1](#).

noon line

(on a dial): simply the [hour line](#) corresponding to noon, it is the most important line from which the others are usually calculated. It is the line which most often carries an [analemma](#).

noon marker

A single mark or stone in the ground (or on a wall) set to show noon when crossed by the shadow of a convenient vertical; for example, a stick or edge of a wall. Sometimes also called a [shepherd's dial](#).

North

The intersection of the local [meridian](#) with the [horizon](#), in the direction of the north [celestial pole](#).

North Pole

The point on the Earth's surface and its [axis](#) with a latitude of +90°
. It lies in the direction of the **North celestial pole**, from which the Earth is seen to rotate anti-clockwise.

numerals

The numerals on dials are usually either [Arabic](#) (the usual 0-9 used in English) or, especially on older dials, [Roman](#) numerals (I, II,...XII etc.). Note that it is common to find IIII in place of the later IV on some dials. A convention sometimes used on dials with more than one hour ring is to use Roman numerals for [Local Apparent Time](#), and Arabic ones for [civil time](#) (often [BST](#) etc.). Many other forms of numerals (e.g. Chinese, Turkish) are used world-wide.

nutation

A small periodic (principal time constant of 18 years 220 days) oscillation of the rotational [axis](#) of the Earth about its mean position. Discovered by James Bradley (1693-1762), the third Astronomer Royal, in 1748. The disturbance of the idealised orbit of the Earth (as a two-body system) is due to the gravitational attraction of the Moon and, to a lesser extent, the other planets. Nutation introduces small changes, typically 7 arcseconds annually, to the [precession](#) of the [equinoxes](#).

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O

obelisk

: a tall tapering shaft of stone, usually monolithic with a square or rectangular section ending with a pyramidal apex. Prominent in Ancient Egypt as a solar symbol, often at the entrance to tombs or as a cult object in shrines to the sun.

obliquity (of the ecliptic)

[**e**, **EPS**] is the angle between the Earth's [equatorial plane](#) and the [ecliptic](#). The current mean value of the obliquity (i.e. ignoring its [nutation](#)) is 23° 26' 21", decreasing by 23" over the next 50 years. Note that this figure sets the position of the [tropics](#).

obtuse angle

An angle of greater than 90° and less than 180°.

occidental

West-facing (e.g. a [direct-west dial](#)). In more general usage, it generally means of, or from, the west.

orbit (of the Earth)

The path of the Earth around the sun. For dialling purposes, this is taken as elliptical, with a very small [eccentricity](#), i.e., it ignores the small perturbations due to the effects of the Moon and other planets.

origin

The (0,0) point (or (0,0,0) in three dimensions) of a co-ordinate system used to describe a [dial plane](#). It is usual to place this point at the [centre](#) of the dial (if it exists), but it is sometimes placed at the [sub-nodus](#) point.

oriental

East-facing (e.g. a [direct-east dial](#)). In more general usage, it generally means of, or from, the east.

orrery

A physical model of the solar system, used for demonstration purposes. Named after Charles Boyle, 4th Earl of Orrery, who had an early example built by John Rowley in 1712. Sometimes powered by clockwork to provide the correct relative orbital periods of the planets. Early examples are very valuable. See also [tellurian](#).

orthography

The art of drawing anything without perspective, as though viewed from infinity. In dialling, the sphere so drawn consists of circles, straight lines and [ellipses](#). Hence orthographic (or orthogonal) projection, which is used in the universal astrolabe.

ortho-style

A style which is perpendicular to the dial plate. It was used in many ancient dials.

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P

parabola

: a mathematical term for the [conic section](#) obtained by cutting a cone with a plane parallel to its generator (or “edge”). A **parabolic** surface, obtained by rotating a parabola about its own axis, is much used for mirrors as it has the property of focusing parallel rays of light to a point focus.

parallactic angle

[?

] the angle of the polar triangle between the directions to the [pole](#) and to the [zenith](#) at the celestial object. Hence it is the angle between the vertical and the [hour circle](#), of use in calculating the effects of astronomical [refraction](#).

parallax: the effect whereby the apparent position or direction of an object changes with the observation point. See [solar parallax](#) for its affect on solar parameters. The effect can affect the accuracy of reading scales.

paschal moon

The first full moon following the Spring [equinox](#). Important for the determination of Easter.

patina

Coloured, metallic compounds (usually oxides and sulphides) which form on metal surfaces left exposed to the atmosphere. The actual colour depends principally on the metal, but also on the impurities in the atmosphere resulting from pollution or proximity to the sea. Typically, copper-containing alloys develop a greenish colour.

pedestal

The supporting structure for a dial, particularly horizontals. Usually of stone, it may comprise several different pieces and brings the dial to a convenient viewing position. See [Appendix VII](#) for more details of architectural terms.

pelorus

An instrument for finding the solar [azimuth](#), consisting of a magnetic compass and an [alidade](#), with some means (e.g. mirrors, prisms, shades) of viewing the Sun and the compass needle.

penumbra

The area of partial shadow surrounding the central [umbra](#). It is due to the finite size of the sun. An observer standing in the penumbra would observe only part of the sun's disk.

perigee

Orbit when it comes closest to the Earth.

perihelion

The point in the Earth's [orbit](#) when it comes closest to the sun. It occurs during the first week of January.

perpetual calendar

A device, usually in the form of a circular plate with one or two rotating engraved disks, for finding the day of the week for any date (over a wide range of years). They are often combined with [portable dials](#) as part of a [compendium](#). More sophisticated versions have extra tables for Saint's Days and similar data.

phase (or age) of the Moon:

the approximately monthly variation of the angular separation of the Sun and the Moon, leading to the sequence of new, waxing, full and waning moons. The **age** (as seen, for example, in tables associated with [moon dials](#)) is measured in days since the last new moon. Astronomically, the phase of the Moon is defined as the angle between the Sun and the Moon measured from the Earth (the [lunar angle](#)). The mean length of the [synodic](#) (i.e., lunar) month is 29.53059 days (usually approximated to 29½ days in the lunar mechanisms of clocks).

photosphere:

The outer envelope of the Sun which produces the visible light by which it is seen.

pinnules

Sighting pinholes (usually in pairs) in an alignment device, e.g. an [alidade](#).

planet

Astronomically, a celestial body in orbit around a star. The five planets of the solar system known to the ancients were Mercury, Venus, Mars, Jupiter and Saturn. In addition, they often counted the Sun and the Moon as planets; for example, in the [planetary hours](#) system. See [Appendix VIII](#) for symbols.

planetarium:

see [orrery](#).

planisphere

A map of part of the [celestial sphere](#), formed by a [stereographic projection](#) of the sphere onto a flat plane and showing (or adjustable for) the positions of the stars at a particular time and location.

plinth

The base part of a [pedestal](#), normally resting on the ground. Note that some authors use ~ to refer to the whole of the pedestal. See [Appendix VII](#) for more details of architectural terms.

plumb-line

A freely suspended line with a weight (or plumb-bob) at its lower end, used for defining the vertical.

plummet

The form of [plumb-line](#) incorporated in a portable dial and used for levelling it. It usually consisting of a solid elongated cylinder suspended, by a joint with free movement in the horizontal axes, above a datum point.

pobble

The bead on the [plumb-line](#) of a [card dial](#).

polar axis

See [axis](#).

polar co-ordinates

See [co-ordinates](#).

polar distance

The distance (as an angle) of the Sun from the elevated [celestial pole](#); the complement of the [declination](#).

polarised light

Light in which the electromagnetic waves have a single plane of vibration in a direction perpendicular to the direction of propagation. Polarising filters allow the transmission of light rays with only a selected plane of polarisation. Discovered by Christiaan Huygens (1635-1703). [Sunlight](#) is randomly polarised, but [skylight](#) is partially plane polarised, with the direction of polarisation at any point in the sky being perpendicular to the plane containing the point, the Sun and the observer. The proportion of the skylight which is polarised is a maximum in the [principal plane](#) and at 90° to the sun. The proportion is always less than 75%, and substantially less in slightly hazy conditions.

Polaris (or Pole Star)

Actually a Ursae Minoris, it is the star which appears quite close to the N [celestial pole](#) and is frequently used for finding north by navigators. It currently appears to rotate daily around a circle of radius 1°, so it requires some knowledge if it is to be used for aligning a sundial. The size of this circle varies over the centuries with the [precession](#) of the equinoxes.

polar plane

Any plane which is parallel to the Earth's [axis](#).

polar triangle

The **spherical triangle** on the **celestial sphere** whose vertices are at the **pole**, the **zenith**, and a celestial body, with respective angles of the **hour angle**, the **azimuth**, and the **parallactic angle**. The arcs joining these are the **co-latitude**, the north polar distance ($90^\circ - \delta$) and the **zenith distance**. The polar triangle is fundamental to the operation of most types of sundial, whose function it is to derive the hour angle, and hence the time, given any three of the other quantities.

poles (N and S of the Earth

): the locations on the Earth's sphere with **latitudes** of $+90^\circ$ (N) and -90° (S).

polos

An old term for a polar-pointing **style**.

post meridiem (p.m.)

The portion of the day between **noon** and **midnight**.

precession (of the equinoxes)

The slow westward progression of the **equinoxes** on the **ecliptic**. It is caused by the drift of the Earth's **axis** in space, as in a precessing spinning top. The position of **Polaris** turns around the pole of the **celestial pole** once in about 26,000 years. As a consequence, the vernal equinox regresses by about 50 arcseconds per year along the ecliptic. It is caused predominantly by the gravitational force of the Sun and the Moon on the Earth's equatorial bulge. Secondary effects, due to the other planets, give a rotation of the ecliptic plane of 47 arc-seconds per century.

The first measurement of precession was made by Hipparchus in 129 BC.

precision (of a dial)

A combination of the **resolution** and **accuracy** of a dial, it gives a measure of how exactly (and correctly) it indicates any time.

Prime meridian

The **meridian line** defined as the origin for **longitudes**. Now synonymous with the **Greenwich meridian**, before 1884 various countries defined their own origin. The early Greeks used Rhodes or Alexandria. **Ptolemy** used the Fortunate Islands, assumed to be Ferro in the Canary Islands by scholars in the Renaissance. **Nuremberg** was common for dials made there, and in relatively modern times many maritime nations had their own locations; Paris in particular continued to be used even post-1884. Note that the 0° longitude line used by the **GPS** system is actually a mean value, periodically recalculated to allow for tectonic drift etc. and currently lies approximately 38 m (80 feet) east of the Greenwich line.

Prime vertical

The vertical circle perpendicular to the **meridian**. It passes through the E and W points.

Primum Mobile

An old term for the supposed crystal sphere carrying the stars in their orbits around the earth.

principal plane {or vertical plane}

The plane obtained by varying the Sun's **altitude** whilst its **azimuth** is constant. Perpendicular to the **almucantar**.

prosthaphaeretical arc: a term introduced by Samuel Foster to describe an arc on the surface of the earth between the location of an [inclining/declining](#) dial and the position where it would be identical to a horizontal dial (i.e. the [complementary](#) dial). In astronomy, prosthaphaerisis is the adding of a small amount to an observed value.

Ptolemy's rulers

An interconnected set of three linear scales used to measure the angular positions of stars, used particularly by Regiomontanus and the Nuremberg group in the 1460s

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Q

Qibla line:

sometimes found on Arabic dials, it is an [azimuth](#) line on the [dial plate](#) starting at the [centre](#) and pointing to Mecca.

quadrant

A term used for a large genus of astronomical and navigational instruments. In the form of a quarter-circle, it incorporates a sun or star sighting device along one of its radial edges and a plumb-bob hanging from the centre of the circle. The old **quadrans vetus** was originally an Islamic invention which provides [seasonal hours](#) but is only truly accurate for an observer on the equator. The **quadrans novus**, invented by Profatius in 1288) was more accurate, incorporating the circular scale of the [astrolabe](#) folded into a quadrant but it was difficult to read. The 1438 **horary quadrant** of von Gmunden was one of several attempts to improve on this. The **Gunter** ~ (after Edward Gunter, Gresham College, 1623) is latitude dependent and employs a [stereographic](#) projection. The **navigational** ~ is actually an octant (eighth of a circle) with two reflecting mirrors replacing the plumb-bob. For the **Davis** ~, see [back-staff](#).

Quarter days: the first or last days of each quarter of the year on which rent or interest is due. These dates

are occasionally used instead of the [zodiac](#) signs for [declination lines](#) on dials. See Appendix XII for their names and dates.

quincunx

Five dots arranged as on dice. It sometimes appears on [mass dials](#) at [noon](#) or service times.

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R

radian

: [rad] the primary unit of angular measurement, it is the central angle subtended by an arc of a circle equal in length to its radius. 2π radians = 360° or 1 rad $\sim 57.3^\circ$.

ray

A single line or narrow beam of light.

reclination

A term sometimes used for the angle by which a [reclining dial](#) leans away from the observer (i.e. the complement of the [inclination](#)). It is more consistent, however, to translate this into the equivalent [inclination](#).

rectificatory

An old term for a right-angled triangle where the other two angles are the [latitude](#) and [co-latitude](#). Used particularly in the graphical construction of dials.

reflex angle

An angle of greater than 180° .

refraction

The “bending” of light at the interface of two materials of different refractive indices. It accounts for the focusing action of lenses. In dialling, use is made of ~ in dials which use a clear liquid in a solid cup to compress the hour lines, or which use a cylindrical lens to focus [sunlight](#) onto a curved [dial plate](#). **Atmospheric refraction** (due to the curve of the Earth’s surface and the variation of atmospheric density with height, in turn dependent on meteorological conditions) is the effect which makes the Sun (or other celestial body) look slightly higher in the sky than its true astronomical position. It is only significant when the Sun is within a few degrees of the [horizon](#). At 0° altitude, the bending is equivalent to approximately 34 arc-minutes, so that it is possible to see the Sun when it has actually just sunk below the horizon. See [Equations](#). This effect is not generally included in normal sundials but it must be allowed for when calculating solar parameters from observations using [meridian lines](#).

The refractive index [μ

, μ] of a medium (or its index of refraction), needed to calculate these effects, is defined as the ratio of the speed of light in a vacuum to its speed in the medium.

Regiomontanus houses

An astrological division of the [celestial sphere](#) into 12 segments or houses. The division is performed in equal segments around the [celestial equator](#), rather than around the [ecliptic](#) as is done for the normal signs of the [zodiac](#). The houses are numbered I to XII, beginning at the east point of the horizon and are, confusingly, associated with the standard zodiac signs with I corresponding to Aries. Only the last 6 of the signs appear above the horizon. They are shown as [domifying circles](#) on some old dials.

resolution (of a dial)

The smallest time increment to which the scale on a dial can be read. Contrast with [accuracy](#). See also [precision](#).

rete

Been used as a graduated scale fixed to an astronomical telescope.

reticule

Fine lines or scales on an optical element in a sighting device (e.g. a telescope) to aid in alignment or measurement of an object.

revolve

To orbit around another body, e.g. the Earth revolves around the Sun. Contrast to [rotate](#).

right ascension:

[α , RA] a co-ordinate used by astronomers, as part of the [equatorial co-ordinate system](#), (together with [declination](#)) to define the position of a celestial body. It is the angular distance measured along the [celestial equator](#) (positive to the east) from [the vernal equinox](#) to the intersection of the celestial equator to with the [hour circle](#) through the point in question. Usually measured from 0 to 24 hours, but sometimes 0° to 360°.

root (of a gnomon)

The fixing between the [gnomon](#) and the [dial plate](#). See [Figure 1](#)

rotate

To spin on its own axis, e.g. the Earth rotates on its polar [axis](#). Contrast to [revolve](#)..

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S

Samhain: an ancient Celtic festival held on the 1st of November. It is one of the [cross-quarter days](#).

saros cycle

A cycle of 18 years 11 days 8 hours (223 [lunations](#)) between repetitions of [eclipses](#).

scales: see [dialling scales](#).

sciagraphy

The art or science of shading and shadows. From sciaterics or scioterics – the name for gnomonics in ancient Greece.

seasons

The seasons are defined astronomically as follows:

Spring: from the vernal

[equinox](#)

to the summer

[solstice](#)

Summer: from the summer solstice to the autumnal equinox

Autumn: from the autumnal equinox to the winter solstice

Winter: from the winter solstice to the vernal equinox

In popular parlance, the seasons of the northern hemisphere comprise the following months:

Spring March, April, May

Summer June, July, August

Autumn September, October, November

Winter December, January, February

The signs of the [zodiac](#) for the seasons are given in [Appendix I](#).

second (of angle):

See [arc-second](#).

second

. Fluctuations in the Earth's rotational rate since about 1969 have been such that the day is between 1 and 3 ms longer than this number of seconds. These variations are totally insignificant to even the best sundial. The word ~ derives from the Latin "secunda minuta" or second minute.

semidiameter

. As the distance from the Earth to the Sun varies during its [orbit](#), the semi-diameter varies from 15.76 arc-minutes in July to 16.29 arc-minutes in January. In dialling, it is usual to take the sun's full diameter as $\frac{1}{2}^\circ$

septentrional

A term now rarely used for "of the north" and sometimes applied to north-facing dials.

shadow sharpener

Any of the various devices for sharpening the edge of a shadow, allowing more accurate time readings to be made. Usually a physical addition to the [gnomon](#) or [nodus](#), it casts a secondary shadow, with its own [penumbra](#), in which the primary shadow can be located more accurately (although it may have less contrast). The term is sometimes also used to refer to a movable lens which produces an image of the shadow edge.

shadow square

A square (or rectangular) scale often found on [quadrants](#) and [astrolabes](#) which allows the tangent or cotangent of the [altitude](#) of a celestial body to be found.

shortest day: a term in common parlance, defined as the day of the year with the least (astronomical)

[sunrise](#) to sunset period. It is normally used synonymously with the winter [solstice](#) although, strictly, it can vary by a day depending on the exact time of the solstice and the relationship between the rate of change of the [EoT](#) and that of the local sunset/sunrise.

sidereal time, sidereal day

See [time](#) (types of).

signs of the zodiac

See [Zodiac](#).

Sirius

The brightest star in the night sky, used by the Egyptians as a means of determining the beginning of the Nile floods. See [heliacal](#) rising.

skylight

Light which reaches the observer from the general (blue) sky. It is [sunlight](#) which has undergone multiple scattering events with the molecules of the Earth's atmosphere (i.e. Rayleigh scattering) or with clouds or other aerosols in the atmosphere. High levels of skylight reduce the contrast of a shadow. It also tends to be [polarised](#).

slant

See [obliquity](#).

small circle

A circle on the surface of a sphere whose centre does not coincide with that of the sphere (and hence it must always have a smaller diameter).

solarium

Latin for sundial. Beware, it can also be interpreted as “sunning place”.

solar compass

An instrument for direction finding which uses dialling principles. The most common are modified versions on an [analemmatic dial](#) with a vertical [gnomon](#). Sometimes called an **astro-compass**, although these latter more properly use sightings of the fixed stars.

solar longitude

The [ecliptic longitude](#) of the Sun, it varies from 0° (at the vernal [equinox](#)) to 360° during the year. By [Kepler's Second Law](#), the rate of change of the solar longitude is such that the Earth sweeps out equal areas on the ecliptic plane in equal times.

solar parallax: the difference between the Sun's [altitude](#) as observed from the Earth's surface and its true

astronomical value from the centre of the Earth./

solar time

See [time\(types of\)](#).

solstices

The same as the [longest](#) and [shortest](#) days, respectively. Astronomically, they are the occasions when the Sun's [ecliptic longitude](#) is 90° or 270°, respectively, and correspond to the extreme values of [declination](#). See [Figure 1](#).

South

One of the [cardinal points](#) of the compass, it is the direction opposite north, in the direction of the south celestial pole. It is also the direction of the Sun at local [noon](#) (in the northern hemisphere).

southing

Another term for a southern [transit](#).

South Pole

The location on the Earth's surface where it intersects the [axis](#), and opposite the [North Pole](#). It has a [latitude](#) of -90°.

spherical angle

The angle whose vertex is at the intersection of two [great circles](#) of the [celestial sphere](#). Spherical trigonometry deals with spherical angles and triangles.

spherical triangle

The figure formed on the surface of a sphere by three intersecting [great circles](#). The **fundamental** (or **nautical**) triangle is the special case of a spherical triangle on the [celestial sphere](#) with vertices at the [zenith](#), [North celestial pole](#) and the [Sun](#).

split noon

See [noon gap](#).

standard time zone

[TZ] a geographical region which uses the same [civil time](#). These are approximately regions between two lines of [longitude](#), set 15° apart, and hence with 1 hour time difference between adjacent zones. The standard time for each zone is the [mean solar time](#) at the central or standard meridian for the zone. For the UK, which is in Zone 0, the standard meridian is the [Prime Meridian](#) at Greenwich, and the zone nominally extends from 7½° W to 7½° E. For political reasons, other time zones have their boundaries adjusted to follow country borders or other features. The zones were defined at the same international conference in 1884 that set Greenwich as the Prime meridian.

steradian

Unit of solid angle. It is the central solid angle of a sphere subtended by a surface area equal to the square of its radius. The whole sphere supports an angle of 4p steradians around its centre.

stereography

. Its use was advocated by 17th century diallists.

string gnomon

A [gnomon](#) in the form of a flexible cord which is pulled tight when the dial, typically in [diptych](#) form, is opened.

style

{stile}: the line in space which generates the shadow edge used to indicate the time on the [dial plate](#). Note that a [gnomon](#) with finite thickness will have two styles (one along each of the upper edges) which will each be operational for parts of every day. If the gnomon is in the form of a long rod, the style will be the virtual line running along the centre of the rod and the dial is read by estimating the centre of the shadow. Note: this modern distinction between gnomon and style is not the one found in earlier literature where (from 1577) the word style was used to indicate a polar-pointing gnomon (a [polos](#)) or, more rarely, a [nodus](#). Hence **stylar**: pertaining to the style or gnomon of a dial (first used 1688). See [Figure 1](#).

style height

[SH] of a polar style is the [angle](#) that the style makes with the [sub-style](#) line. Note that this is an unusual use of the word “height”, and **style angle** could be regarded as a better term. For a style which is perpendicular to the [dial plane](#), style height is simply the distance from its top to the foot. See [Figure 1](#).

sub-nodus (point)

The point on the [dial plane](#) that lies perpendicularly below (or behind for a vertical dial) a [nodus](#). The distance from this point to the nodus is sometimes called the **ortho-style distance**.

sub-style angle

[SD] the angle that the sub-style makes with the noon line, measured positively clockwise (towards the p.m. hours for a south-facing vertical dial).

sub-style (line)

The line lying in the dial plane which is perpendicularly below (or behind for a vertical dial) the [style](#). See [Figure 1](#).

sub-style triangle

The right angled triangle formed with the polar [style](#) as the hypotenuse, with the other sides lying along the [sub-style](#) and the [ortho-style distance](#).

summer solstice

; see [solstices](#).

Sun

The star at the centre of our solar system. The mean distance to the Earth (designated the Astronomical Unit or AU) is 149.6×10^6 km. It has a surface temperature of about 5800 °

K. The solar spectral irradiance reaching the Earth's surface (at AM1 – air mass 1 – i.e. looking through a standard atmosphere with the Sun at the [zenith](#)) ranges from about 250 nm to 2000 nm, with the main peak at 490 nm. See [semi-diameter](#) for the apparent size of the Sun.

sun clock

See [Dial types](#).

sun compass

See [solar compass](#)

sundial

An instrument for telling the time and/or date from the position of the Sun. More generally, it can give any function of the Sun's co-ordinates. See [dial](#) for the origins of the term, and [Dial \(types of\)](#) for types.

sunlight

Light reaching the observer [directly](#) from the Sun. Contrast with [skylight](#). Note that the Sun's rays reaching the Earth are always taken as parallel, but coming from an extended source (see [semi-diameter](#)).

sunrise, sunset

The first (last) appearance of the Sun above the [horizon](#) each day. This occurs when the sun's [altitude](#) reaches $-0^{\circ} 50'$. Note that astronomers define the rising of an object as an altitude of 0° . The difference is due to the combined effects of the Sun's mean [semi-diameter](#) (16 arcmin) and [atmospheric refraction](#) (34 arcmin). See [Equations](#) for expressions to calculate sunrise and sunset.

sunshine recorder

A meteorological instrument for recording the hours in which the Sun shines. The most interesting type is the **Campbell-Stokes ~**, which uses a spherical lens to focus bright sunlight onto a paper chart, burning a track along it.

superior

Refers to an event on the [celestial sphere](#) above the [horizon](#). Opposite of [inferior](#).

synodic

Pertaining to the successive conjunctions of a planet (or moon) with the Sun

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T

tellurian

: a demonstration model, similar to an [orrery](#), but showing the Earth-Sun system, or the Earth-Sun-Moon system. This latter is sometimes referred to as a **lunarium**. Note: the tellurian is sometimes called a tellurium but this term is best avoided as it is the name of the 52nd element in the periodic table.

terminator:

The edge of the shadow cast by a self-shadowing object, such as the edge of the illuminated part of the Moon.

terrella

From the Latin for “little globe”. See [globe dials](#).

tide(s)

The divisions of a day used in the Anglo-Saxon period. The time from [sunrise to sunset](#) was divided into four tides or time periods. See [Appendix II](#) for the names of the tides. Lines showing the tides are found on [Anglo-Saxon](#) and some [mass](#) dials. Some dials also have lines denoting the half-tide. Note that this use of the word has no connection with the marine tides.

Time, (types of):

Apparent solar ~:

the measure of time based on the diurnal motion of the true sun.

British Summer Time

: **[BST]** [civil time](#) in the UK during the “summer”, one hour ahead of [GMT](#). Invented by William Willett and first introduced in 1916. A sundial showing BST in Petts Wood, near Chislehurst, Kent, is his memorial. BST usually begins on the last Sunday in March, and ends on the last Sunday in October. These dates are now co-ordinated with Summer Time in the rest of the EU.

civil ~

The legally-accepted time scale in a particular country or region. It is based on the [standard time](#) for that [standard time zone](#), but may have fixed differences (eg [BST](#)). Measured in [modern hours](#) from the most recent [midnight](#), with either a 24 hour or 2 x 12 hour format.

clock ~

Simply the times shown by a clock, usually [civil](#) time. Hence the appendage “o’clock” to some times.

Daylight Saving Time

: **[DST]** [civil time](#) during the summer in much of the USA (and some other countries) obtained by advancing clock time one hour from local standard time. Equivalent to [BST](#) in the UK.

dynamical ~

[or Terrestrial Dynamical Time, **TDT**] “scientific time” – it superseded [ephemeris time](#) in 1984, and is based on a uniform scale of time derived from atomic clocks (i.e. not subject to fluctuations in the Earth’s rate of rotation). Now usually called **international atomic time (TAI)**.

ephemeris ~: **[ET]** “scientific time” – used between 1960 and 1983, this uniform timescale was based on the [ephemeris second](#), itself derived from the period of rotation of the Earth at a particular date. It was succeeded by [dynamical](#) time when the [second](#) was redefined in 1984.

French revolution ~

A decimal timescale (10 equal hours or decadays per day) devised in 1790 by the French Academy after the French Revolution. Each hour was divided into 100 millidays (of 86.4 seconds) and each milliday into 1000 microdays (0.0864 seconds each). The decimal timescale, which had been used previously in ancient Egypt and China, was never fully implemented and was quickly dropped, with the result that sundials so calibrated are extremely rare.

Greenwich Mean Time

: **[GMT]** the basis for [civil time](#) standards worldwide, it is the time at Greenwich as given by the fictitious mean sun. It is derived from [UT](#).

Local Apparent Time

: **[L.A.T.]** – the use of the full-stops is encouraged to avoid confusion with the common contraction of “latitude”] this is [solar time](#), as derived from the real Sun at any particular location. It is the [hour angle](#) of the Sun + 12 hours. Some authors (non-UK) may refer to it a Local True Time.

local mean ~ {mean ~}

: **[LMT]** this is [solar time](#) which has been corrected for the [EoT](#) but not for [longitude](#), so it is still location specific. English towns used this form of time prior to the coming of national railways and the telegraph, e.g. Oxford time.

Mean Solar Time

The authoritative (by the National Physical Laboratory) definition is: a measure of time based conceptually on the diurnal motion of the fictitious mean Sun, under the assumption that the Earth's rate of rotation is constant.

railway ~

A colloquial term used for Greenwich time as it began to replace local time with the introduction, in the mid-1800s, of railways and the resulting need for unified timetables.

sidereal ~

: **[t, SDT]** “astronomical or star time”. This is timekeeping based on the [sidereal day](#), and hence it runs ahead significantly with respect to solar-based time. **Local sidereal time** is equal to the [hour angle](#) of the first point of Aries and is, to a first approximation, sidereal time with a [longitude correction](#).

solar

~: the same as [Local Apparent Time](#).

Summer time

A generic term for [BST](#), [DST](#) etc.

standard

~: **[ST]** is [mean solar time](#) at the central meridian of a given [time zone](#).

universal

~: **[UT or UTC]** this is the basis for terrestrial and civil timekeeping, and was adopted in January 1972. It is tied to the rotation of the Earth, and hence has to be periodically adjusted by the addition of [leap seconds](#) to account for the gradual slowing of the Earth, and the vagaries of its rotation. UT is by definition measured from the [superior transit](#) of the fictitious [mean sun](#) (i.e. mean [noon](#) at Greenwich), and hence is 12 hours behind [GMT](#) (although this difference only tends to be recognised by astronomical calculations). UT measurement is based on standard [seconds](#). The version referred to as **UTC (Universal Time, Co-ordinated)** simply means the value averaged over a number of atomic clocks world-wide. In aviation, it is referred to as Z or zulu.

zonal solar time

Sometimes used to denote solar time at a [time zone](#) meridian. Thus it is [local apparent time](#) with a longitude correction but without EoT. In the UK, it would be denoted **Greenwich Solar Time**.

– End of Time (types of) –

time zone: see [standard time zone](#). torquetum: (pron. tor-kwet-um) an early (known to be before 1326 AD) astronomical instrument capable of fixing star positions and producing conversions between equatorial and ecliptical co-ordinates. Some forms may have been used to help delineate dials, and torquetum-style dials for solar and [sidereal](#) time were made in the late 17th century. Most famously, it features amongst the instruments in Holbein's 1533 painting "The Ambassadors" (National Gallery). transit: the meridian passage of a celestial body. For the sun, this occurs when it is directly south of the observer. It can also refer to the time of this occurrence. Transits may be either [superior](#) or [inferior](#). transom: a crosspiece of fixed length, as on a [cross-staff](#). Sometimes called a **vane**. triangle (fundamental or nautical): see [spherical triangle](#).

triens

An extended quadrant, with a 120° arc. It can usually tell the time in both [equal](#) and [unequal](#) hours.

trigon

In dialling, a mechanical aid to drawing lines of [declination](#) on [dial plates](#). It consists of an instrument which is fitted to, and can swivel around, the [nodus](#) on a polar-pointing [gnomon](#), and can be set at an angle equal to the sun's declination angle to the gnomon. Often used with an associated [auxiliary](#) dial. Trigon is also an archaic term for a triangle. From the Greek "trigonon" or three-cornered.

triptych

Literally "three leaves", it refers to a set or [compendium](#) of three instruments, including at least one dial. Other instruments often include a compass and perpetual calendar.

tropical year

See [year](#).

tropics

Geographical bands of the Earth's surface, extending from the equator to latitude 23°

26' N (tropic of **Cancer**) or to 23°

26' S (tropic of **Capricorn**). The terms are also used to refer to these specific latitudes. Note that they represent the extremes of the region where the Sun can reach the [zenith](#) when the sun's [declination](#) is at its extreme values.

twilight

The interval after [sunset](#) or before [sunrise](#) when the Sun illuminates the upper atmosphere and hence it is not completely dark. It is determined by the sun's [altitude](#) falling within a given range, as follows:

civil twilight: -0° 50' and -6°

nautical twilight: -6° and -12°

astronomical twilight: -12° and -18°

These values reflect the need for decreasing light levels for various activities.

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U

umbra

: the central, darkest portion of a shadow, i.e. the region which does not receive direct rays from any part of a distributed light source (e.g. the Sun).

umbra recta

Latin for “upright shadow”, it is the label often found on the cotangent scale of [altitudes](#) $< 45^\circ$ on a [shadow square](#).

umbra versa

Latin for “reverse shadow”, it is the label often found on the tangent scale of [altitudes](#) $> 45^\circ$ on a [shadow square](#).

Universal Time (UT

): see [time \(types of\)](#).

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V

vernal {spring}

equinox: see [equinoxes](#).

verdigris

The green [patination](#) found on weathered brass and copper.

vernier

A small moveable scale for obtaining fractional parts of the subdivisions of a fixed scale. Invented by Pierre Vernier in 1631 (published Brussels, 1638). For circular scales, a Type A vernier has a central zero. After about 1780, sextants commonly had a Type B vernier with the zero on the right of the scale. European instruments often have the very similar [nonius](#).

vertical angle

The angle from the [zenith](#) to the [horarius circle](#) passing through the sun, measured along the [prime vertical](#) (the E-W vertical circle). It is one of the [ptolematic co-ordinates](#).

vertical plane

See [principal plane](#).

volvelle

Tides etc. A ~ has sometimes been included around the rod-gnomon of [equiangular](#) dials.

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W

wedging out

: (or **canting out**) placing wedges between a dial plate and its mounting surface. (a) for a [horizontal dial](#): to compensate for moving a dial to a different [latitude](#) from the one it was designed for, (b) for a [vertical dial](#): to ensure that it faces a [cardinal point](#) of the compass (usually S).

West

: the point on the [horizon](#) 90° (measured anti-clockwise) from the [north](#) point. The Sun appears to set at the west point at the [equinoxes](#).

winter solstice

See [solstices](#).

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The BSS Sundial Glossary

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Y

Year: the time that it takes the Earth to make one orbit of the sun. The **tropical year** is the interval in which the mean [ecliptic longitude](#) of the Sun increases by 360°. This is the version of the year used in normal calendars and has a length of 365.24219 days. Other versions of a year (e.g. the sidereal, anomalistic and Julian years) have differences of about a hundredth of a day to this figure.

Yule: an ancient Celtic festival held on or around the 21st of December, celebrating the winter solstice. It is one of the [cross-quarter days](#), and has now become synonymous with Christmas.

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Z

zenith: (astronomical) the point on the [celestial sphere](#) vertically above the observer. In everyday parlance, ~ usually implies the highest point. This gives rise to confusion as the mid-day Sun is often described as its ~, irrespective of the [latitude](#).

zenith distance

[z] the complement of the [altitude](#) i.e. ($90^\circ - a$)

zodiac

An imaginary band, centred on the [ecliptic](#), across the [celestial sphere](#) and about 16° wide, in which the Sun, Moon and the planets Mercury, Venus, Mars, Jupiter and Saturn are always located. The band is divided in 12 intervals of 30° , each named (the **Signs of the Zodiac**) after the constellation of stars which it contains. The sun's [ecliptic longitude](#) may be measured against this scale. The names (and/or signs) of the constellations are given in [Appendix I](#) and are often used in sundials, instead of the date, to specify [declination](#) lines etc. Because of the effects of [precession](#) over the period of 2,300 years since the constellations were first named, the signs of the zodiac have slipped by a whole sign, i.e. at the [vernal equinox](#) (defined as the first point of [Aries](#)), the Sun is actually in the constellation of Pisces.

Zonwvlak

A major suite of computer programs for calculating sundial lines. Written by Fer de Vries (Netherlands) it is available at www/iaehv.nl/users/ferdv. The name is short for zonnewijzer (sundial) vlak (plane).

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Horizontal Sundial Nomenclature (Northern Hemisphere Version)

N.B. In the Southern Hemisphere the numerals run anti-clockwise around the dial plate.

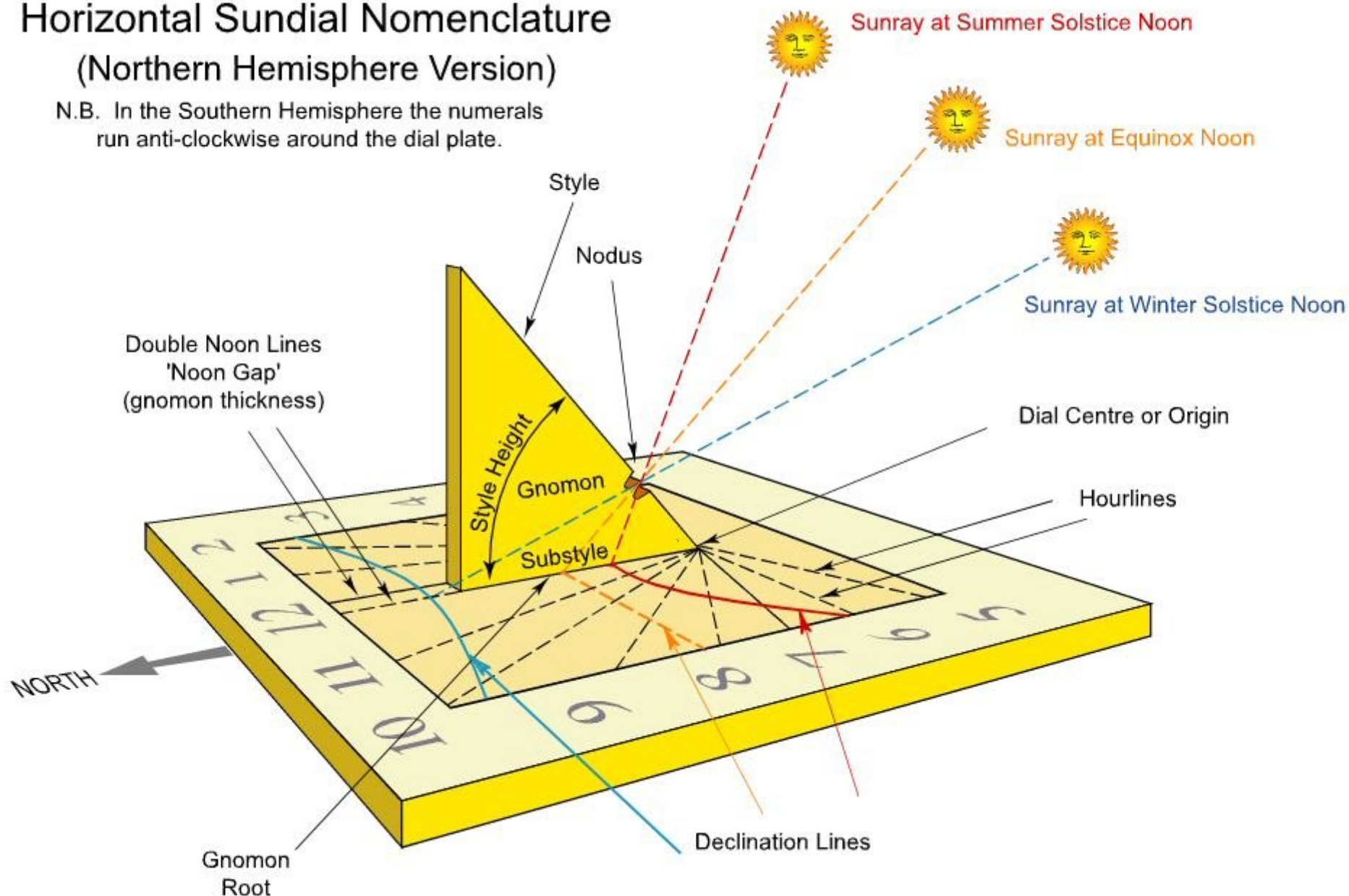


Figure 1. Basic sundial nomenclature

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BIOGRAPHIES

The following brief biographies includes astronomers, mathematicians, architects, craftsmen and authors worldwide who have contributed to gnomonics. Some of the subjects are better known in other fields, but their contributions to dialling are stressed here. This is by no means a comprehensive list, but does include the most important figures. For a much more comprehensive listing of British dial makers, see:

J. Wilson: 'Biographical Index of British Sundial Makers from the Seventh Century to 1920', British Sundial Society (2003).

Abbreviations:

c. (circa) approximate date.

fl. (flourished) period known to have been working.

d. died.

Spelling:

Individuals names in the period before 1700 showed much variation, even by their owners. Those used here are the ones most commonly found. although some alternatives are shown where known.

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Airy, George Biddell 1801-1892: was an English astronomer and Astronomer Royal from 1835 until 1881. Amongst many scientific achievements, he introduced an improved system of *meridian* observation and introduced many new instruments to the Greenwich Observatory, including the Airy transit circle which re-defined the *Greenwich Meridian* which, largely through his efforts, was accepted as the *Prime Meridian* in 1884. He introduced the electrical timing of transits in 1854, and the daily recording of sunspots using the Kew *heliograph* in 1873. He determined the exact *longitudes* of Paris, Edinburgh, Brussels and Cambridge, helped with the mapping of the Canadian/American border, and assisted in the construction of the clock chimes for the Westminster Tower.



Allen, Elias fl.1606-1654: was the most famous mathematical instrument maker of his day, and is sometimes regarded as

the father of the English instrument making industry. He was born in Kent and may have undertaken estate surveys when young. He was first established with a shop in Blackhorse Alley, near Fleet St., London, in 1606-11 but later moved to the Sign of the Horse Shoe, Strand. He specialised in instruments of brass and silver, giving instructions in their use. Allen was the second in a long line of master-apprentice relationships, training under [Charles Whitwell](#) and with his most notable apprentice being the renowned [Ralph Greator](#), leading through [Henry Wynne](#) to [Thomas Tuttell](#). He was a friend of [William Oughtred](#), for whom he made [double horizontal](#) dials and who described him as 'a man well knowne and esteemed by all men of art for his skilfullness in making instruments of metal'. The high quality of his engraving can be seen in his instruments in the British Museum, the Science Museum, London, the Museum of the History of Science in Oxford, the Whipple Museum, Cambridge, and St. Andrews University, Edinburgh.

Abbo of Fleury c.C11: a French Benedictine monk who produced an [horologium](#) in the late C11 which gave shadow lengths for his location at each hour and for each month.

Adams, George senior fl.1760-1772: was a Fleet St., London, instrument maker. He served his apprenticeship under [Thomas Heath](#), and went on to become instrument maker to King George III. He made, for example, a number of large [horizontal dials](#). He was succeeded by his sons George jnr. (1750-95) and Dudley (1760-1826).

Albategnius (or **Abu-'Abdullah Muhammad ibn Jabir Al-Battani**) 858-929: was an Arab astronomer (born Haran, Turkey, died Samarra, Iraq) who refined [Ptolemy's](#) work with careful measurements, particularly of the length of the year and the [precession](#) of the equinoxes. He was also a brilliant mathematician who extended plane trigonometry to the surface of a sphere (spherical trigonometry). His work, including the invaluable [cosine rule](#), became known in Europe during the Renaissance.

Alhazen (or **Abu Ali al-Hassan ibn al-Haytham**) c.965-1038: was born in Basra (now in Iraq) and was the greatest scientist of the Middle Ages, particularly in the field of optics. He wrote a treatise on Arabic astronomical instruments, including many forms of sundial, and which noted the innovation of a [polar style](#) to produce [equal hours](#). He contested the views of Hero and [Ptolemy](#) that vision involves rays emerging from the eye, postulating that light originates from the sun or a flame. He made and described lenses and spherical/parabolic mirrors, and measured the [refraction](#) of light. He also postulated that rainbows are formed in the atmosphere. His chief work was published in 1572 as 'Opticae Theasurus' from a 13th century Latin translation.

Anaxagoras c.500-428 BC: a Greek astronomer who gave the correct explanation of solar and lunar [eclipses](#), hypothesised that the moon is observed by reflected light, and maintained that all heavenly bodies are composed of rocky material.

Anaximander the Elder c.611-547 BC: an Ionian natural philosopher, he helped bring the knowledge of the ancient Egyptians, and others, to Greece. He also introduced the sundial there. This dial with a vertical [gnomon](#) enabled him to ascertain the lengths and angles of shadows, thereby allowing him to measure the lengths of the [years](#) and [seasons](#), and set the times of the [equinoxes](#) and [solstices](#). He envisaged the Earth as a cylinder (sic) with its axis running E-W, floating in space.

Apian, Peter (or **Apianus** or **Bennewitz**) 1495-1552: discussed [quadrants](#) in his 'Instrument Buch' of 1533, and also developed the [Apian dial](#) (a universal [card dial](#)). Some of his famous dials still exist in Austria.

Apollonius of Perga c.245-c.190 BC: was the last of the great Greek mathematicians. His great work was on the [conic sections](#). His work on [epicycles](#) and [ellipses](#) formed the basis for [Ptolemy's](#) cosmology. A sundial named the [arachne](#) is attributed to him by [Vitruvius](#).

Aristarchos of Samos c.320-250 BC: was probably the first astronomer to propose a heliocentric theory of the solar system. This had the Earth and the planets circling the sun, with the stars infinitely distant. He was able to make some (inaccurate) estimates of the sizes and distances of the sun and the moon by noting that the moon must lie at the right angle of a triangle with the sun and Earth when it is half illuminated. The document that describes this, 'On the Magnitude and Distances of the Sun and the Moon', still exists.

Arsenius, Gualterus Regnerus c.1525-c.1580: was a master instrument maker in the Low Countries, who graduated from the university of Louvain in 1546. He often signed himself on instruments as the 'nephew' of the mathematician [Gemma Frisius](#) and, although it is uncertain if they were actually related, Arsenius certainly succeeded [Mercator](#) as Gemma's instrument maker. His main output was [astrolabes](#), but he also made, for example, a magnificent bowl [scaphe dial](#) with an astrolabe lid.

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Bacon, Roger 1214-1294: was an English philosopher and scientist. He was Franciscan friar educated in Paris and Oxford. At the Pope's request, he wrote a three-volume encyclopaedia on all the known sciences. Although he suffered religious persecution, he developed magnifying glasses, made proposals for a telescope, and promoted the use of [latitude](#) and [longitude](#). He also wrote to the Pope suggesting calendar reform as the [equinox](#) date was in error by 9 days.

Bede St. (known as the Venerable Bede) c.673-735 AD: an English monk, theologian and historian who lived in a monastery at Jarrow, Northumbria. He wrote 'the Ecclesiastical History of the English People' (731 AD), a primary source for English history. His work 'Horologia' contained tables of shadow lengths for different times of the year, and also compared the day-lengths in Jarrow with those in Italy (though he never travelled far from Jarrow). His 'De temporum ratione' of 725 gave a table of the [paschal](#) cycle. He wrote in Old English vernacular, and also in Latin, and his work survives through manuscripts copied by his pupils. His Feast Day is 27 May.

Bion, Nicholas fl.1652-1723: a well-known Parisian instrument maker who made many [Butterfield dials](#) – indeed, he may have originated the style. He also wrote an influential treatise 'The Construction and Principal Uses of Mathematical Instruments' in 1709 (translated into English by Edmund Stone in 1723).



Blagave, John c.1558-1611: a mathematical practitioner from Reading, educated at St. John's College Oxford. He is best known for

his 'Mathematical Jewel', which was a uranical *astrolabe*, (using a *stereographic projection*) and was described in a book called 'The Mathematical Jewel' published in English in 1585. It contained much material on dialling and in 1609 he published 'The Art of Dyalling' dedicated to the subject. Being a strong Protestant in this Elizabethan period, he was able to adopt and promote the *Copernican* system. He also designed a map of the world in 1596 (now in the British Museum). His monument, in St. Laurence's church, Reading, features five cherubs each holding a *Platonic solid*.

Bloud, Charles fl. second half C17: was a French dial maker working in Dieppe. He is best known for his *magnetic azimuth dials*, usually in ivory, although he also made standard *diptych dials*.

Bradley, James 1693-1762: was the third Astronomer Royal. He was educated at Balliol College, Oxford, where he studied theology and he was a vicar in Bridstow. He resigned a position as chaplain to the Bishop of Hertford in 1721 to become Savilian Professor of Astronomy at Oxford. Bradley is famous for discovering the *aberration of light* (and hence correctly determining the speed of light), and for accurately describing the *nutation of the earth*.



Brahe, Tycho 1546-1601: often known by his first name only, he was the last of the great naked-eye astronomers. Born of

aristocratic parents, he was educated in Copenhagen in law and philosophy, but took up astronomy after observing the 1560 solar eclipse. After working in Basle, King Frederick II of Denmark offered him the island of Hven in 1576 for what is regarded as the first observatory of its kind in the world. Brahe was the last great astronomer to reject the heliocentric theory of *Copernicus*, although he did suggest that the planets other than the Earth revolved around the sun. His carefully prepared tables of the motion of the sun allowed him to determine the length of the year to within a second, making calendar reform inevitable. Tycho moved to Germany in 1597 and took as his assistant *Johannes Kepler*. Kepler made great use of Tycho's data. Brahe was also an instrument builder, producing advances in a number of instruments, including an improved *transversal scale* for *quadrants*.

Butterfield, Michael b.1635, fl.1674-1724: was born in England but moved to Paris at an early age. He had a workshop 'Aux Armes d'Angleterre', and was, uniquely, granted his own coat of arms. He has given his name to the portable *Butterfield dial*, although he was not the only maker and probably was not the originator. As his workmanship was of the highest quality, many other makers signed their dials 'Butterfield à Paris'.

Briggs, Henry (1561-1630): was the Savilian Professor of Geometry at St. John's College, Cambridge, and the first holder of the chair of geometry at *Gresham College*. He was a colleague of *Gunter* and worked with *Napier*, producing tables of logarithms to base 10 in 1617. He made the famous sundials on the east buttresses of the Merton College, Cambridge, chapel, which still exist.

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Cassini, Giovanni Domenico (or Jean Dominique) 1625-1712: was a brilliant Italian-born astronomer who moved to France in 1669 to set up the new Paris Observatory. Before moving, he had been Professor of Astronomy at Bologna University, and had set up the great *meridian line* of San Petronio in 1653, allowing him to publish accurate tables of the sun in 1662. Although a well-regarded observational astronomer who had influence with the Pope and the French King, he was slow to adopt the *Copernican* system and insisted (wrongly) that the earth was flattened at the Equator, despite arguments from *Newton* and *Huygens*. He was the head of a dynasty of four generations of astronomers at the Paris Observatory.

Chaucer, Geoffrey c.1342-1400: was an English poet and author. His most famous work, 'Canterbury Tales', includes at least one reference to a sundial – the *chilindrum*. It is also cited as the first occurrence of the phrase 'of the klokke' (*o'clock*), showing that *equal hours* were already becoming known. The prologue to the Parson's Tale relates shadows and time in a manner consistent with *equal hours*. Additionally, he wrote a treatise on the *astrolabe*.

Clavius, Christopher c.1580: an Italian astronomer working in Rome. He published 'Gnomonices Libri Octo', a complete synthesis of the theory and practice of gnomonics. He did much of the work that led to the *Gregorian* calendar reform.

Cole, Humphrey (or Humfray Colle or a bewildering number of variants on his instruments) c.1525-1591: is the best-known of the Elizabethan instrument makers, with examples of high quality workmanship being found in many museums. Born in the north of England, he moved to London and was probably a member of the Goldsmiths' Company. He was an assistant at the Mint in 1564 and set up his own workshop 'near the North door of St.Paul's'. It is possible that he was a student of *Nicholas Kratzer*. He made principally *quadrants* and *rules*, often incorporating dials. There are also existing examples of *horizontal*, *ring* and *equinoctial dials*. His masterpieces include the two-foot astrolabe dated 1571 at the University of St. Andrews and the misnamed 'Drake's astrolabe' (*compendium*) at the National Maritime Museum..

Copernicus, Nicolaus (Mikolaj Kopernigk) (1473-1543): was a Polish astronomer and cleric who was responsible for finally overturning the geocentric theory of the cosmos. He was educated at Krakow and Bolgna, and spent most of his working life as the Canon of Frombork. He only made a small number of astronomical observations, relying on other people's data. His model of the planets orbiting the Sun, with the axis of the Earth tilted by 23.5°, was largely correct, although he retained the system of epicycles. His ideas were first formulated and circulated in 1513 and 1530, but publication of his master-work 'De Revolutionibus Orbium Coelestrum' was delayed until he was on his deathbed. It remained on the Roman Catholic Church's index of forbidden books from 1616 until 1835.

Culpeper, Edmund 1660-1738: There were actually two Edmund Culpepers (father and son) together with a grandson Edward. They were all accomplished instrument makers; a signed *horary quadrant* with a sundial on the reverse is in the Whipple Museum, Cambridge.

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Daniel, Christopher St. J.H. 1933- : was one of the founders of the BSS, and is its current chairman. After a career at sea and as a curator at the National Maritime Museum, Greenwich, he is now a freelance sundial designer. His most notable dials include the famous 'Dolphin dial' at the National Maritime Museum, and the four vertical dials on St. Margaret's Church, Westminster. He is also author of the Shire book 'Sundials' which has helped to re-popularise the subject in the UK.

Democritus c.460-c.370 BC: was a Greek philosopher (born in Thrace) who travelled to Egypt and the East. He is mainly remembered for introducing the term 'atom' for tiny indivisible particles which make up the whole universe. He also drew the first maps with rectangular grids i.e. an early form of *latitude* and *longitude* and wrote a treatise 'Polographié' on the *polos*.

Drecker, Joseph c.1925: A German historian, author and scholar, he wrote the influential and rather mathematical 'Die Theorie der Sonnenuhren' including the definition of *planetary hours* used here.

Dyson, Frank Watson 1868-1939: was an English astronomer educated at Trinity College, Cambridge. He was Astronomer Royal for Scotland (1906-1910) and for England (1910-1933). His main area of research was stellar motion but he was also deeply interested in solar phenomena, being actively involved in two solar *eclipse* expeditions, including Arthur Eddington's famous one which confirmed the General Theory of Relativity. Dyson was also passionately interested in time measurement and initiated the first public broadcasting of time signals by the BBC over radio – the familiar six-pip signal.

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Emerson, William 1701-1782: was an English mathematician and teacher who lived at Hurworth, County Durham, where at least one of his dials can still be seen. His tomb is in the churchyard and the village pub, the Emerson Arms, is named after him. His 'Dialling, or the Art of Drawing Dials...' was published in 1770 and gave a good description of geometrical dialling.

Emilianus, Palladius c.C5: wrote 'De Re Rustica' in about 450 AD. This *horologium* gave the shadow lengths in Sicily for every hour of the day for each month, and was much used by scholars such as *Bede* and *Abbo of Fleury* in future centuries.

Eratosthenes c.276-c.194 BC: a Greek scholar and polymath, born in Cyrene (now part of Libya). He was appointed as the librarian of the famous museum of Alexandria in 235 BC. He is best known for measuring the circumference of the Earth by means of the difference in noon shadow lengths from a vertical gnomon in a hemispherical bowl between Alexandria and Syene. His value of 46,500 km compares quite well with the modern figure of 40,075 km at the Equator. Eratosthenes also managed to measure the *obliquity of the ecliptic*, obtaining a value of 23° 51', and introduced the concept of the tropics, temperate zones, and polar regions.

Evans, Lewis: a collector of portable dials and astrolabes in the early 20th century. One of his forebears had been an assistant at the Greenwich Observatory. In 1924 he donated his collection to be the foundation of the Oxford Museum of the History of Science.

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Fale, Thomas c.1555-c.1610: a Caius College, Cambridge, mathematician, credited with publishing the first work in English devoted to dialling. It is 'Horologiographia: the Art of Dialling', completed 1586 and first published 1593. This was substantially a translation from the Latin of Wittekind's treatise of 1576.

Ferguson, James 1710-76: was sent to Edinburgh University by patrons. He became a prolific writer and lecturer in natural philosophy, able to make his own apparatus and instruments. He wrote specifically for the non-mathematical public. His main contribution to dialling was the publication in 1770 of 'Lectures on select subjects: with the use of Globes, the art of dialling, etc.' A signed instrument engraved 'The Universal Dialling Machine and Solar Time-Finder' is at The National Maritime Museum.

Finé, Oronce (or Orontius Finaeus) 1494-1555: was the diallist to Francis I of France. He published a number of books of solar horology (e.g. 'Protomathesis', 1532). He was an approximate contemporary of *Nicholaus Kratzer*, and performed a similar rôle as Kratzer's for the English king. He was an astrologer as well as an astronomer and mathematician, and was jailed in 1518 for an unpopular horoscope. An ivory *navicula* signed by him still exists. He produced a world map which coined the named 'Terra Australia', and wrote on the use of lunar *eclipses* to determine *longitude*.



Flamsteed, John 1646-1719: the first Astronomer Royal of England. In 1665, at the age of 19, he made the first accurate

tables of the [Equation of Time](#) in England – ‘De Aequatione Dierum’ (published in 1669). He was educated at Jesus College, Cambridge, and was also a clergyman with the living of Burstow, Surrey. He became King Charles II's ‘Astronomical Observator’ at the newly established Greenwich Observatory in 1675. He was a fastidious observer who invested heavily in the best instruments available. His book ‘Doctrine of the Sphere’ in 1680 gave a new determination of the solar [eccentricity](#) at almost its true value of 0.01675. He made a precise determination of the [latitude](#) of Greenwich, the [obliquity of the ecliptic](#), and the position of the [equinoxes](#). He also produced tables of atmospheric [refraction](#), tidal tables, and supervised the compilation of the first table describing the inequality of the lunar ecliptic following [Kepler's second law](#). Flamsteed's main body of work, including star maps and detailed observations, was only published posthumously (‘Historia Coelestis Britannica’ in 1725, and ‘Atlas Coelestis’ in 1729), despite the fact that they were needed by his contemporaries [Isaac Newton](#) and [Edmond Halley](#). He probably never made a sundial, although his papers show that he had dial construction in mind and he certainly corresponded with dial makers, particularly in his early years.

Foster, Samuel c.1600-1652: was an English mathematician and astronomer, and was amongst the first-rank of 17th century diallists. He was born (probably) in Coventry and educated at Emmanuel College, Cambridge. After a period teaching in Coventry, he became the Professor of Astronomy at [Gresham College](#), London, in 1636. As a Puritan, he suffered persecution, forcing him to return to Coventry between 1637 and 1641. He published ‘The Art of Dialling’ in 1638, providing the first printed account of the use of Latitude and Hour [scales](#) for dial design. At this stage the scales were drawn out on a [quadrant](#), rather than the ruler-like layout adopted by George Serle. The book also introduced the [prosthaphaeretical arc](#) for solving the [spherical triangle](#) when constructing [inclining/declining](#) dials. Foster constructed a [geographical dial](#) of great complexity on the internal wall of the astronomy professor's chambers at [Gresham College](#). Following his death, several books were published from Foster's manuscripts. These included ‘Elliptical or Azimuthal Horologigraphy’ (1654) which had three important sections. One of these developed the mathematics of the [analemmatic dial](#) for the first time in English. The second considered dials on arbitrary planes with movable styles, now known as [Foster-Lambert dials](#). The third deals with rectilinear or the [diametral](#) designs not covered elsewhere.

Fourier, Jean Baptiste Joseph 1768-1830: was a French mathematical physicist who was principally interested in heat. His mathematical methods for harmonic analysis, called Fourier analysis (and f. series, integrals, transforms etc.) are now widely used to describe mathematical functions, e.g. the [EoT](#).

Franklin, Benjamin 1706-1790: the famous American President and scientist, he showed a great interest in dialling. In a humorous essay, he proposed a form of [noon gun](#) with an different number of canon on each hour line. He also strongly championed the use of [Daylight Saving Time](#).

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Galileo (properly, **Galileo Galilei**) 1564-1642: one of the greatest scientists ever, he was born in Pisa (where he famously demonstrated the acceleration due to gravity) but he also worked in Florence and Padua. He discovered the isochronal properties of the pendulum, invented the thermometer and was one of the earliest users of the refracting telescope. This he improved and developed to study the surface of the moon and to discover the satellites of Jupiter, which he suggested could be used to measure *longitude*. His 'Siderius Nuceus' (Starry Messenger) of 1610 showed the 'imperfections' of the heavens, and brought him into conflict with the Church. The imperfections included sunspots, which moved with time. After the new Pope Urban VIII was elected, Galileo published his 'Dialogue Concerning the Two Chief World Systems' in 1632, clearly favouring the *Copernican* system. The book was banned and Galileo convicted of heresy, dying later under house arrest and reportedly muttering 'Yet it does move'.

Gatty, Margaret (Mrs Alfred Gatty) 1809-1873: a Victorian author on a wide variety of subjects, famous amongst diallists for her book 'The Book of Sundials', first published in 1872. The first edition consisted mainly of dial *mottoes*, but later editions (by her daughter H.K.F. Eden and Eleanor Lloyd, but still referred to as 'Gatty') carried much more material.

Gemini, Thomas (T.G. or TC on dials) c.1515-62: a map engraver (trained with *Mercator*) and instrument maker from Flanders who migrated to London around 1540. A superb calligrapher and engraver, he made extant astrolabes and quadrants: one of the earliest known English horizontal dials (in the Science Museum) is dated 1551 and attributed to him.



Gemma Frisius, Regnier (or Regner, Reiner) 1508-1555: was born in Friesland in the Low Countries (hence his nickname)

and became a professor of medicine and mathematics at the University of Louvain. He cooperated with his student *Mercator* in the construction of maps, globes and astronomical instruments. These included the form of *astrolabe* named after him and which he described in 'De Astrolabio' in 1556, a new *cross-staff*, and both terrestrial and celestial globes. In his 1530 book 'De Principiis Astronomiae Cosmographicae' he showed theoretically, for the first time, how *longitude* could be found with an accurate clock and also described the method of trigonometric surveying.

Gibbs, George c.1880-1947: was a consulting engineer and astronomer from Yorkshire. He was at one time the Director of the Jeremiah Horrocks Observatory, Preston. He is best known as the designer of the high-quality Pilkington & Gibbs *heliochronometer*, marketed from around 1906 until the First World War. He later fell out with his financial partner William Pilkington. A Foucault pendulum which he set up is in the Preston Museum.

Gibbs, Sharon L: a modern historian whose 1976 treatise 'Greek and Roman Sundials' is the standard text on the subject.

Gilbert, Sir William 1544-1603: the physician to Elizabeth I and an early physicist, admired by [Galileo](#). Born in Colchester, Essex (where his house Timperlys is now a clock museum and features a horizontal dial outside). He described the newly-discovered [magnetic variation](#) and described making metal magnets in his 1600 treatise 'On the magnet'. He was also the first Englishman to accept the astronomical system of [Copernicus](#).

Greatorex, Ralph (or Gratrix) fl.1654-1712: was a London mathematical instrument maker and surveyor. He served his apprenticeship under [Elias Allen](#) and later took over his business. He was a friend of both [William Oughtred](#) and Samuel Pepys, for whom he made several instruments. He made portable dials amongst many other instruments. There is a horizontal string-gnomon dial by Greatorex in the Horniman Museum (London).

Gregory, James 1638-75: a professor at St Andrews and Edinburgh, he was a famous mathematician (discovering an infinite series that sums to pi) and astronomer. He is best known for inventing the Gregorian (reflecting) telescope in 1661. He employed men such as John Knibb and [Henry Wynne](#) to furnish the Observatory at St Andrews, and the [meridian line](#) in the Long Gallery of the university library at St Andrews is attributed to him.

Gunter, Edmund 1581-1626: was born in Hertfordshire and educated at Christ Church, Oxford. He taught mathematics for some years before becoming the third Professor of Astronomy at [Gresham College](#) 1619-26; he was also a Rector in Southwark (1615-26). He designed a large and complicated sundial for the King's Privy Garden at Whitehall; the dial was demolished in 1697, though Gunter's descriptive book of 1624 survives. In orientating the dial with John Marr by use of a magnetic compass, [magnetic variation](#) was discovered. He also developed the Gunter [quadrant](#) and a precursor to the slide-rule. He published seven-figure tables of logarithms, sines and tangents in 'Canon Triangulorum' (1620) which also coined the terms cosine and cotangent and the contractions sin and tan.

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Halley, Edmond (or Edmund) 1656-1742: an English astronomer, best known for describing the orbit of the comet named after him. He studied at Oxford and although he did not obtain a degree he published a book on [Kepler's Laws](#). He made an expedition to St. Helena to study the southern skies, and was appointed as the second Astronomer Royal in 1720. He was a friend of [Newton](#), being partly instrumental in getting him to publish the 'Principia'. He had wide scientific interests, publishing papers on the rainbow, tides, magnetism etc. He made a study of [Ptolemy's](#) writings and hypothesised that the apparent position of the stars had altered over the 15 centuries since the original observations had been made. Although he is not known to have had a direct input to dialling, his work at that period had a great influence on the underlying principles.

Hawney, William fl.1710-50: was a mathematics teacher from Lydd in Kent. He undertook land-survey, supplied sundials and quadrants for house and garden as well as teaching the whole range of simple practical mathematics and the use of mathematical instruments. According to custom he made his teaching notes into books. 'The Doctrine of Plain and Spherical Trigonometry' (1725) contains 87 pages devoted to 'Dialling, Arithmetical and Instrumental, on all sorts of Planes'.

Heath, Thomas fl.1714-1765, d.1773: a celebrated London mathematical instrument maker who was born in Luton and apprenticed to [Benjamin Scott](#). He later went into partnership ('Heath and Wing') with his son-in-law, the mathematical practitioner, surveyor and almanac maker [Tycho Wing \(Jnr\)](#). Amongst his other apprentices were [George Adams](#) senior and John Troughton. A famous Heath dial is at Penshurst Place, Kent. He is particularly well known for his large [universal equinoctial ring dials](#).

Herschel, Frederick William 1738-1822: was originally a German musician but emigrated to Britain in 1757 and became a celebrated astronomer and the foremost telescope maker of his time. In 1800 he examined the solar spectrum using prisms and thermometers, discovering the existence of the infrared solar energy. By using [Maskelyne's](#) data, he established for the first time that the sun was not fixed in the universe, and he was also able to measure the sun's velocity relative to seven bright stars. His house in Bath is now a museum, and has an [armillary sphere](#) in the garden.

Hevelius, Johannes (or Hewel or Hewelcke) 1611-1687: a German astronomer, mostly famous for his careful charting of the moon. Between 1642 and 1645 he produced a fairly accurate value for the period of the solar rotation, and gave a good description of the structure of sunspots, coining the term 'faculae'. His observations of the sun over this period are detailed in an appendix to his 'Selenographia'.

Hipparchus c.190 BC- after c.126 BC: a great Greek astronomer and mathematician, born in Nicaea (now in Turkey). His star maps (using a system of [celestial latitude and longitude](#)) were of great accuracy for their time, were extensively copied by [Ptolemy](#), and were used much later by [Halley](#). From the movements of the star Spica over 150 years, he deduced a value of around 45 arc-seconds for the annual [precession of the equinoxes](#) (cf. the modern value of about 50.26"). He measured the length of the tropical [year](#) as 365¼ days and obtained a value of the lunar period which was only 1 second too short. Despite these accuracies, Hipparchus accepted the notion of a geocentric universe, with the Earth not quite at the centre of the sun's orbit. He also contributed in the field of mathematics with one of the earliest formulations of trigonometry.

Horne, Dom. Ethelbert 18xx-19xx: was an English priest who lived and worked at Downside Abbey, Somerset, for most of his life. He published extensive reviews of [mass dials](#) – 'Primitive sundials or scratch dials' in 1917 and 'Scratch dials – their description and history' in 1929.



Huygens, Christiaan 1629-1695: the most famous Dutch astronomer, mathematician and physicist. He invented the

accurate pendulum clock and produced the first accurate table of the [Equation of Time](#) in 1665. He republished this table in his 'Horologium Oscillatorium' in 1673.

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John of Holywood: see *Sacrobosco*.

Jackson, Joseph fl.1735-1760: was an important mathematical instrument maker who was a member of the Guild of Grocers and served his apprenticeship under [Thomas Heath](#). One of his horizontal dials can be seen at Wandlebury, Cambs.

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Kepler, Johannes 1571-1630: was a German astronomer who is famous for [Kepler's laws](#) of planetary motion. His interest in astronomy was sparked by the Great Comet of 1577. As a Lutheran, he suffered with religious persecution throughout his life and went to Prague as [Tycho Brahe's](#) assistant in 1600. Kepler completed Tycho's observations after his death (the celebrated [Rudolphine Tables](#) of 1627) and made use of them to formulate his laws of planetary motion. His first two laws were published in his 'Astronomia Nova' of 1609. By postulating elliptical orbits, he finally broke the [Ptolemaic](#) cosmos and

provided a firm footing for the [Copernican](#) one. His 'Mysterium Cosmographium' had earlier (1596) shown that the five [Platonic](#) solids (regular polyhedrons) could be fitted inside a series of spheres to match the distances of the planets from the Sun (within 5%). Kepler also wrote the first science fiction book, 'Solemnium', in which a man travelled to the moon.

Kircher, Athanasius fl.1636-1646: was a polyglot Jesuit priest who lived with his students in the Collegio Romano, Rome. His magnum opus 'Ars Magna Lucis et Umbrae' (The great art of light and shadows) shows designs for many complex dials, some of which were not previously known and some of which (e.g. magnetic gnomons, light projection with sound and fire) are fanciful. He is credited by some authors with the introduction of the [signs of the zodiac](#) on [declination lines](#). Some of his dials were made as the 'Sciatheric Tables'; four table-tops made of slate.



Kratzer, Nicholas (or Nicolas) c.1487-1550: born in Munich, Bavaria, he studied at the University of Cologne and at the

Carthusian Monastery of Maurbach, near Vienna, where he learned his dialling skills. He came to the court of King Henry VIII in 1517/8 as an astronomer and 'deviser of the king's horologies', and as tutor in Sir Thomas More's household. He also entered Cardinal Wolsey's service, lecturing at Oxford at Corpus Christi College (1521-24). Only four dials can definitely be attributed to Kratzer. One is a small gilt brass octagonal dial now in the Oxford Museum of the History of Science. A stone dial, made in 1520 but rejected as incorrectly made, was found as part of a wall and is now in the City of Bristol Museums and Art gallery. The two others, now lost, were a pillar dial at St. Mary's Church, Oxford – the source of inspiration for the famous Turnbull or 'Pelican dial', and a multiple cube dial at Christ Church College. This latter dial has recently been used as the basis for David Brown's prize-winning dial, also at Christ Church. Kratzer is famously depicted, together with numerous dialling instruments and partially completed dials, in the 1528 portrait by Hans Holbein (the Younger), currently in the Louvre, Paris. A 1520 portrait by Albrecht Dürer has been lost.

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Lambert, Jean Henri (or Johann Heinrich) 1728-1777: was born in poverty in the Alsace and was a self-taught mathematical prodigy. He worked in Switzerland and Germany (for the Emperor of Prussia) as a private tutor. He was a multi-talented scholar, publishing on mathematics, physics, astronomy and philosophy. He is remembered amongst diallists for devising a form of analemmatic dial with a circular scale (the [Foster-Lambert dial](#)) and for [Lambert's circles](#). He also developed (1772) several map projections still used today, including a conic projection and the Universal Transverse [Mercator projection](#).

Leybourn(e), William 1626-1716: principally a London-based publisher, he was also an author and mathematical practitioner. His first work dedicated to dialling, in 1669, was 'The Art of Dialling: performed geometrically by scale and compasses; arithmetically by the canons of sines and tangents; instrumentally by a trigonal instrument.....'. It became a standard work, and the third edition in 1721 was called 'Dialling Improv'd'. His great work on dialling was 'Dialling: plain, concave, Convex, projective, reflective, refractive.....'. He was a contemporary of [John Flamsteed](#) and [Henry Wynne](#).

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Mach, Ernst 1838-1916: was an Austrian physicist, now remembered for the Mach number, describing supersonic velocities. Amongst his many interests, he investigated the stimulation of the retinal field with spatial patterns and discovered the strange visual effect now called [Mach bands](#). This was subsequently forgotten and rediscovered in the 1950s.

Maskelyne, Rev. Nevil 1732-1811: an English astronomer and the fifth Astronomer Royal. He studied divinity at Trinity College, Cambridge, but went to the Greenwich Observatory instead of taking up a living. Although recently portrayed as the villain in the battle with John Harrison to win the [Longitude](#) prize (he was both a competitor and, later, a member of the Longitude Board), he was a talented astronomer who made strong contributions to the study of [transits](#). His most enduring legacy for diallists is the Nautical Almanac which he founded in 1767, comprising a compendium of astronomical tables and navigational aids, including many of his observations of the sun, moon, planets and stars. He also observed the proper motion of several stars, and made measurements at a mountain in Perthshire to determine the gravitational constant.

Melville, Richard (sometimes Melvin) fl.1840-1871: a well known and prolific maker of quality decorative dials, he originally worked from Belfast and Edinburgh, but came to England at a later date. He is particularly known for his multi-gnomoned horizontal dials, usually in slate.

Mercator, Gerardus 1512-1594: was a Flemish engraver, cartographer, astronomer, instrument maker etc. He studied mathematics and philosophy at the University of Louvain, and made a living from making and selling [quadrants](#), [astrolabes](#), [armillary spheres](#) and [sundials](#). He is now most remembered for devising the [Mercator projection](#), introduced in his masterpiece map of the world in 1569 and still much used in map making. Several sundials were built in Rupelmonde, Belgium, to celebrate the quatercentenary of his death.



Meton 5th century BC: was a famous Greek astronomer who worked in Athens. Together with Euctemon, he made a series

of observations of the [solstices](#) and, in 432 BC, derived a calendar with a 19-year cycle – the modern [metonic cycle](#). This may have been based on earlier developments in Mesopotamia. He also built a water clock at Colonus, and developed the [parapegma](#).

Molyneux, William (1656-1698): was an FRS and a gifted amateur astronomer, working from Trinity College, Dublin. He corresponded with *Flamsteed* and published his '*Sciothericum Telescopicum*: a new contrivance...' in 1686 describing a combination of dial and telescope. It also included his own version of the *EoT*.

Müller, Johannes: see *Regiomontanus*.

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Napier, John 1550-1617: was an aristocratic Scottish mathematician and amateur scientist, famous for the invention of logarithms, a term which he derived from the Greek words 'logos' and 'arithmos' (expression, number). He devised these because of the difficulty in performing astronomical calculations involving sines, which were well tabulated. The first logarithm tables were published in his '*Mirifici Logarithmorum Canonis Descriptio*' in 1614, although it was only with collaboration from *Henry Briggs* that the standard base-ten form was published in 1617. 'Napier's Bones' were a primitive mechanical computer and comprised numbered rods, usually of boxwood or ivory, which allowed multiplication to be easily performed and square roots to be found. Napier is also credited with the introduction and popularisation of the decimal point.



Newton, (Sir) Isaac 1642-1727: was the foremost British scientist of all time and is often credited with inventing the 'scientific

method'. His birthplace, where he performed his most inspired work in the annus mirabilis of 1665, was Woolsthorpe Manor, Lincolnshire which is now owned by the National Trust. He was educated at Trinity College, Cambridge, where he was made Lucasian Professor of Mathematics at the age of 26. He invented a reflecting telescope in 1673, and gave a good explanation of the causes of the rainbow, later published in his opus '*Opticks*' in 1704. His major work is generally called the *Principia* ('*Philosophiae Naturalis Principia Mathematica*') and was published in 1687 after much prompting and financial support from *Edmund Halley*. In it, Newton described the inverse square law of gravitation, his laws of motion, and set the foundation for the mathematics of calculus. He made two scratched dials as a boy at Woolsthorpe Manor; one is now in the library of The Royal Society, London, and the other is inside Colsterworth church (Lincolnshire). Various other dials, notably the celebrated one at Queens' College, Cambridge, have been ascribed to him, almost certainly erroneously.

Nicholson, Peter 1765-1844: was an English mathematician, born at Prestonkirk in Haddingtonshire. He was largely self-taught. He was one of the leading intellects behind 19th century building technology. In 1833 he wrote '*A Treatise on Dialling*: one showing the geometrical and the other the arithmetical construction....'. He drew many dials for the Newcastle and Morpeth area in it.

Nonius (Filde Nunez Salaciense) 1502-78: was a Portuguese mathematician and astronomer who, around 1540, devised the idea of engraving an *astrolabe* with a series of concentric circular scales (a '*nonius*') to allow accurate determination of an angle. He also discovered that the *loxodrome* on the current maps described a spiral and not a circle.

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Oughtred, Rev. William 1573 (or 1575) – 1660: (pron. Owt-red) was an English mathematician, educated at King's

College, Cambridge. He taught at Albury near Guildford for most of his life. His 'Clavis Mathematica' (the key to mathematics) became the standard mathematics textbook. He showed an interest in dialling early in his career, inventing an easy method of geometrical dialling as an undergraduate. He is most famous for his *Double Horizontal dial*, often referred to as an Oughtred dial, incorporating a projection of the celestial sphere and a vertical style to function as an astrolabe. He designed a popular form of *universal equinoctial ring dial*, and also produced a circular slide rule. He collaborated closely with Elias Allen and was also a friend of Ralph Greatorex.

Ozanam, Jacques 1640-1717: was a French mathematician and member of the Royal Academy of France. His four-volume 'Récréations mathématiques et physiques' (1694) gives comprehensive instructions for dial designs and, in improved form and translated into English, was reprinted as late as 1840.

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Plato (real name Aristocles) c.427-c.347 BC: was a highly influential Greek mathematician and philosopher who founded a school of learning which rejected practical experimentation in favour of mathematical and intellectual harmony. His insistence in the perfection of the heavens, with the planets moving in circles around the earth, held back astronomy for centuries.

Pliny, Gaius Plinius Secundus AD 23-79: known as Pliny the Elder to distinguish him from his nephew, the biographer. Pliny was a Roman military officer who retired to become an author and scientist. All the important assumptions from classical astronomy are described in Book II of his 'Historia Naturalis'. This contains his own views together with, for example, the theories of *Hipparchus* and *Eratosthenes*. He expounded a geocentric universe, with the Earth as the pivot for the heavens and the seven planets (Sun, Moon, Mercury, Venus, Mars, Jupiter and Saturn). The sun was seen as the ruler of the heavens and had a zodiacal orbit around the Earth, divided into 12 equal parts. The sun was allowed 360 days to complete its circuit, with a surplus 5¼ added to bring it back to the 'same' position in the heavens. Although he had no idea of celestial distances, Pliny judged that the sun was much larger than the Earth, and lay at a great distance, by the fact that the shadows of rows of trees are parallel, and that during the equinoxes the sun reaches the vertical simultaneously 'for all the inhabitants of the southern region'.

Ptolemy, Claudius Ptolemaeus c.90-c.170 AD: was an astronomer, astrologer, geographer and philosopher, probably of Egyptian extraction. He worked at Alexandria (then under Roman domination), with access to the famous library there with its works by *Plato*, *Hipparchus*, *Aristarchos* etc. His master-work was the famous 'Almagest', which influenced astronomical and religious conceptions for at least 13 centuries, despite the serious errors which it propagated. Ptolemy's cosmos was geocentric with all the orbits being perfect circles, although not always centred on the Earth. He made much use of epicycles, where the planet rotates around a small circle, which itself rotates around a larger one. Ptolemy also drew maps of Asia and Africa in his collection 'Geography', which included notes on *latitude* and *longitude* which much later influenced Christopher Columbus. His astrological treatise 'Tetrabiblos' has had a deplorable long-term effect. The *Ptolemaic co-ordinates* are named after him.

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Regiomontanus 1436-1476: was a great German astronomer and mathematician who made observations, compiled astronomical tables, assisted in the reform of the *Julian calendar* and was also an active diallist. He was born Johannes Müller in Königsberg, (the king's mountain) which he latinized for his name. He studied in Vienna, where he translated *Ptolemy's* 'Almagest' from Greek into Latin for his posthumous 'Epitome', which also included criticisms of Ptolemy's theories which later influenced *Copernicus*. In 1467 he started compiling astronomical and trigonometrical tables, giving celestial co-ordinates which were useful for latitudes up to 60° N and calculating sine tables (which were not published until 50 years after his death). In 1471 he moved to *Nuremberg*, where he installed a printing press in his house allowing him to publish his own 'Ephemerides' – giving the positions of the heavenly bodies for every day between 1475 and 1506 – as well as scientific works from other authors. Regiomontanus had a strong influence on the Nuremberg group of diallists and dial makers, and described a universal form of *card dial* in his publication 'Quadratum horarium generale' of 1474. He travelled to Rome in 1475 to assist in amending the notoriously incorrect Julian calendar, but died there (probably of the plague) the following year.



Richard of Wallingford c.1292-1336: was an Oxford mathematician and astronomer. He made scientific instruments,

probably including an astrolabe and the famous astronomical clock at the abbey of St. Albans, where he became Abbot. He is thought to have suffered from a form of leprosy, as extant paintings show him with a spotted face.

Rohr, René R-J 1905-1999: was born in Strasbourg and had a long naval career, becoming a captain. He was Honorary Vice-President of the BSS, and wrote many articles on gnomonics. His book on dialling, 'Les Cadrons Solaires' has been translated into English, German and Italian, is still in print and is valuable to modern diallists.

Rowley, John fl.1698 d.1728: was a London instrument maker who turned to large engineering projects after about 1715. He built the first *orrery* for the Earl of Orrery, for whom he also made a *Butterfield dial* (in the National Maritime Museum, together with another for the first Duke of Marlborough). He made two large (29 inch) horizontal dials in 1710 for St. Paul's Cathedral and a set of four for Blenheim Palace, the latter comprising a *double horizontal*, a *geographical*, an *equation* and a *moon dial*. The dial at Cranbury Park, Otterbourne, which is sometimes attributed to *Newton*, is by Rowley. A characteristic of many of his dials is the use of *transversals*, which he may have introduced to dialling.

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Sacrobosco, Johannes (also known as John of Holywood) c.1195, d. between 1244 and 1256: was an astronomer and mathematician who was born in Yorkshire (probably Halifax) and studied at Oxford. He became a professor and taught in Paris. He was one of the first Europeans to use the astronomical writings of the Arabs, and translated *Ptolemy's* 'Almagest'. His 'Tractatus de Sphaera' (commonly known as the Sphere) dealt with the spherical Earth and the heavens, defined the *celestial equator*, the *ecliptic* and *zodiac*, the length of the day and night at different *seasons* and '*climates*' and also gave a (poor) description of the motion of the sun and moon. The Sphere was published in 1220 and remained the basic astronomy textbook until the 17th century, despite numerous errors. Sacrobosco wrote 'De Anni Ratione' in 1232, describing many forms of time and declaring that the Julian calendar was 10 days in error (which he proposed correcting by omitting one day in 288 years). He also wrote on the quadrant in 'Tractatus de Quadrante'.

Sawyer, Frederick W III 1950-: is a co-founder of the NASS and its current President and Editor. He is a graduate of Yale and Pittsburgh universities, where he obtained B.A. and M.A degrees in Mathematics, Philosophy, and History and Philosophy of Science. He has authored more than 65 articles on dialling and is the inventor of the *Equant dial* and the *Ptolemaic co-ordinate* category of dials. He is an expert on the work of *Samual Foster* and has done much original work on dialling theory.

Scaliger, Joseph Justus 1540-1609: was a French scholar and Calvinist who found many supposed errors in Pope Gregory XIII's calendar. In 1583 he devised his own calendar of 7980 astronomical years, counting a day at a time, which is now the basis of the *Julian Daycount*.

Scott, Benjamin fl.1712- d.1751: was a London mathematical instrument maker who moved to the St. Petersburg Academy of Sciences (Russia) in around 1747. He served his apprenticeship under James Anderton and *John Rowley*, and worked in the partnership of Scott & Price 1714-18. He wrote 'The Description and Use of an Universal and Perpetual Mathematical Instrument' in 1733. He made ring, inclining and garden dials and also globes. He also made a magnificent French *double horizontal* dial, now in the Paris museum of science.

Seller, John Snr. fl.1658-1698: a compass, instrument and dial maker, who was also a surveyor and notable mathematical practitioner. He is one of the few makers of *double horizontal* dials. He taught and wrote on the arts of navigation and gunnery, published 'Praxis Navigation' in 1669, was appointed Hydrographer to His Majesty the King, and made measurements of *magnetic variation* at Wapping.

Serle, George: a C17 mathematical practitioner who produced the first set of *dialling scales* on a ruler and described them in a 1657 instruction booklet 'Dialling Universal'.

Singh, Maharaja Jai 1688-1743: an Indian Maharaja and astronomer, he is best known for the series of five monumental naked-eye observatories that he built at various sites in India. The first was at Delhi (1724) but the most famous is at *Jaipur*, where the 'Brihat Samrat Yantra' was until modern times the largest sundial in the world. Singh also wrote a two-volume treatise on the *astrolabe* entitled 'Yantra Raj Karika'.

Sosigenes 1st century BC: was an Alexandrian astronomer to the Egyptian court who wrote several books about the stars (now lost). He strongly influenced the Roman Julius Caesar to reform the calendar (see *Julian calendar*) in 46 BC.

Sutton, Henry fl.1637 d.1665: one of the best-known 17th century instrument makers, best known for his *horary quadrants* and *ring dials*.

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Tompion, Thomas 1638-1713: the leading clockmaker of his day, working from London. He made the two 'Great Clocks' or astronomical regulators for *John Flamsteed* at the Royal Observatory. Amongst his sundials are a famous pair dated c.1690 at Hampton Court, one of them a *double horizontal*. The other dial was copied in 1959, and is at Kew (where the original was from 1832 to 1959). Two portable dials by him, in silver and gold, are in the British Museum. He was one of the earliest adopters of the *EoT* for his clocks and dials.

Tuttell, Thomas fl.1695-1702: was instrument maker to the king. He trained under *Henry Wynne* and made and sold *Serle's* dialling scales in 1700. He popularised a combination of portable horizontal and analemmatic dials which is self-orientating.

Tycho: see *Brahe*.

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Ulugh Beg 1394-1449: a Mongol prince and Muslim of Tartar descent and the grandson of Tamerlane. He built a monumental observatory at Samarkand (now Uzbekistan). It included a huge stone sextant with a radius of 48m with which he could measure to 10 arcminutes and determine the length of the solar year to a minute of time. The remains of the instrument are still extant and his results were used by *Flamsteed*.

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Vernier, Pierre 1584-1638: was a French engineer and instrument maker who devised the precision *vernier scale*. He worked as a military engineer for the Spanish Hapsburgs and the rulers of Franche-Comté, and devised his scale after studying the work of *Nonius*.

Vitruvius Pollio, Marcus fl. 46-30 BC: a Roman soldier (served with Julius Caesar in Africa) and architect. In his retirement, he wrote 'De architectura' which was much translated and very influential in Renaissance Europe. It included two chapters of information on the 13 kinds of sundial, and sundial construction methods, then known.

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Waugh, Albert E 1903-1985: the Provost and Vice President of the University of Connecticut (USA), he is best known to diallists as the author of the 1973 classic 'Sundials: their theory and construction' which is still in print. Waugh had a library of early dialling books (including *Fale* and *Ozanam*), which he bequeathed to the Homer Babbidge Library of his university, where he is commemorated by a *pillar dial*. He also designed many dials, including two at Connecticut's Mystic Seaport.

Wheatstone, Sir Charles 1802-1875: a British physicist whose name is best remembered for the Wheatstone bridge, an electrical circuit which he did not invent himself. He was a Professor of Experimental Physics at King's College, London, working initially in acoustics but also in optics and electricity. His contributions to dialling were the invention of the *polarised light sundial* (1848), and a precision *heliochronometer*: examples of both are in the Science Museum, London. He also contributed considerably to the demise of the sundial through his pioneering work with William Cooke to develop a commercial electric telegraph, which was used to distribute *railway time*.

Whipple, Robert: a great collector of early scientific instruments – particularly portable dials and microscopes – in the early 20th century. He was the managing director of the Cambridge Scientific Instrument Company and donated his instrument collection as the foundation of the Whipple Museum of the History of Science, Cambridge in 1944.

Whitwell, Charles c. 1568-1611: was originally trained as an engraver of maps etc. but went on to become the founder of a long line of instrument makers at the Grocers' Guild. He had *Elias Allen* as an apprentice and worked 'without Temple Barre against St. Clement's Church', London. Numerous instruments, including sundials and *compendia*, are in major museums (including the British Museum and Science Museum).

Wing, Tycho fl.1751 – d.1776: was a mathematical instrument maker who served his apprenticeship under [Thomas Heath](#) and later went into partnership with him. Several high-quality horizontal dials signed “Heath and Wing” are recorded.

Wren, Sir Christopher 1632-1723: is best known as the English architect responsible for St. Paul's Cathedral, London, and the Greenwich Observatory (1675). He also had numerous mathematical and astronomical interests, having invented an astronomical instrument at the age of twelve. In his second year as student at Wadham College, Oxford, he had translated into Latin a treatise on dialling by [William Oughtred](#). Additionally, he had devised a [mirror sundial](#) for the ceiling of his college rooms. Wren's best-known dial is the magnificent 1658 vertical decliner, now found on the south wall of the Codrington Library at All Souls' College, Oxford. It was originally positioned centrally on the south wall of the chapel in the Front Quadrangle, having been removed during 1869. In its original position, the dial with its [diagonal scale](#) could be read to one minute.

Wright, Thomas fl.1718- d.1767: held the appointment of Mathematical Instrument Maker to His Majesty the Prince of Wales, later George III, and was the leading maker of his day. He served his apprenticeship under [John Rowley](#). One of his horizontal dials can be seen at Lacock Abbey, Wilts.

Wynne, Henry (or Wynn) 1640-1709, fl.1654-1709: a London instrument maker who served his apprenticeship to [Ralph Greate](#) and later numbered [Thomas Tuttell](#) and Richard Glynne amongst his apprentices. He is noted for his magnificent [double horizontal](#) dials, such as the one at Drumlanrig Castle. He is also known for his ring dials, and the small book he produced explaining them as well as [moon dials](#). In 1677 Wynne made the magnetic [dip](#) needles with which Henry Bond's [longitude](#) solution was tested. Wynne is also attributed with introducing the domestic barometer.

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APPENDIX VII. Architectural and ecclesiastical terms used in dialling

The following terms, taken from the field of architecture ([Fleming et al](#)) have been adapted to describe architectural features found in dialling. Parts of a church are also included as they are frequently used to describe the location of a dial.

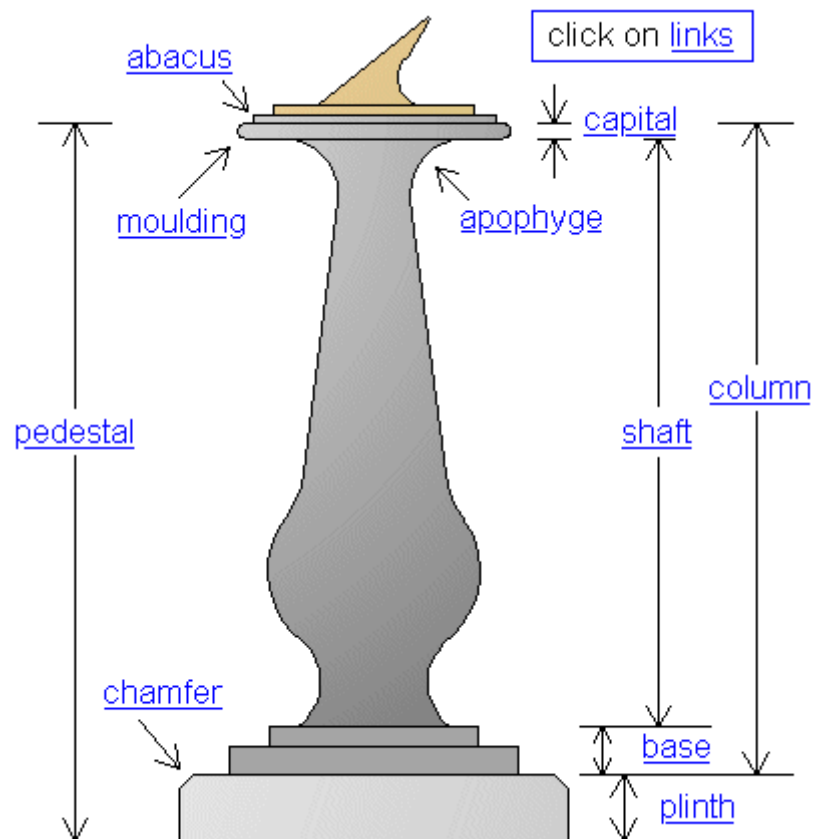


Figure 6. Component parts of a pedestal

abacus: the flat slab on the top of a **capital**, for example, immediately under a horizontal dial on a **pedestal**.

aisle: the part(s) of a church running alongside the central **nave**. There is often a north and a south aisle, and they are usually of lesser height than the nave.

apophyge: the slight curve at the top and bottom of a **column** where it joins the **capital** or **base**.

apse: large semicircular or polygonal recess, arched or dome-roofed, at the end of a church.

baluster: an architectural term for the short pillars which form the supports for a balustrade. The term can be used in dialling to describe the common variety of **shaft** for a **pedestal** which is bulbous towards the bottom and rises to a neck of smaller diameter, similar to that shown in **Figure 6**.

banded shaft: (or blocked shaft) a **column** broken by plain or rusticated blocks of stone.

base: part of a **pedestal** for a dial, it stands on the **plinth** and supports the **column**.

buttress: a mass of masonry or brickwork projecting from or built against a wall to give additional strength.

capital: the head or crowning feature of a **column**. Many stylised forms exist and have special names.

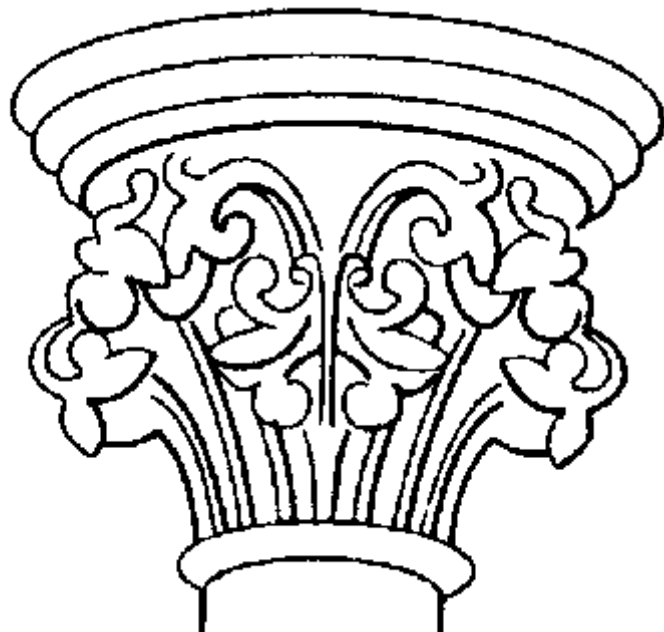


Figure7. A stiff leaf capital

caryatid: strictly, a sculptured female figure used as a **column** to support a dial, etc. It can be used more loosely for other human figures, e.g. **Atlantes** (male caryatids), **Hermes** (three-quarter-length figures), and **Terms** (tapering columns merging at the top into human, animal or mythical figures).

chamfer: the surface made when the sharp edge (**arris**) of a stone block is cut away, usually at an angle of 45° to the other two surfaces. It is called a hollow chamfer when the surface is made concave.

chancel: a part of a church, at its east end and near the altar, reserved for the clergy, choir, etc.

clerestory: part of a wall of a cathedral or large church, with a series of window, above aisle roofs.

column: in classical architecture, it is a part of an **Order**, comprising the **capital**, **shaft** and **base** and is circular or square in cross-section.. This definition can also be adopted for dialling purposes.

compound column: a column comprising a number of merged or semi-merged **shafts**.

corbel: a projecting block, usually of stone, inserted into a wall to support, for example, a vertical dial.

crown: a decoration over the top of a vertical dial as an alternative to a **pediment**.

entablature: the upper part of an **Order**, made up of architrave, frieze, cornice etc. Loosely, everything above the **capital**.

finial: a formal pointed ornament on top of a canopy, gable etc. It is sometimes seen on top of a pillar dial, often in the form of a ball-and-spire or a fleur-de-lis.

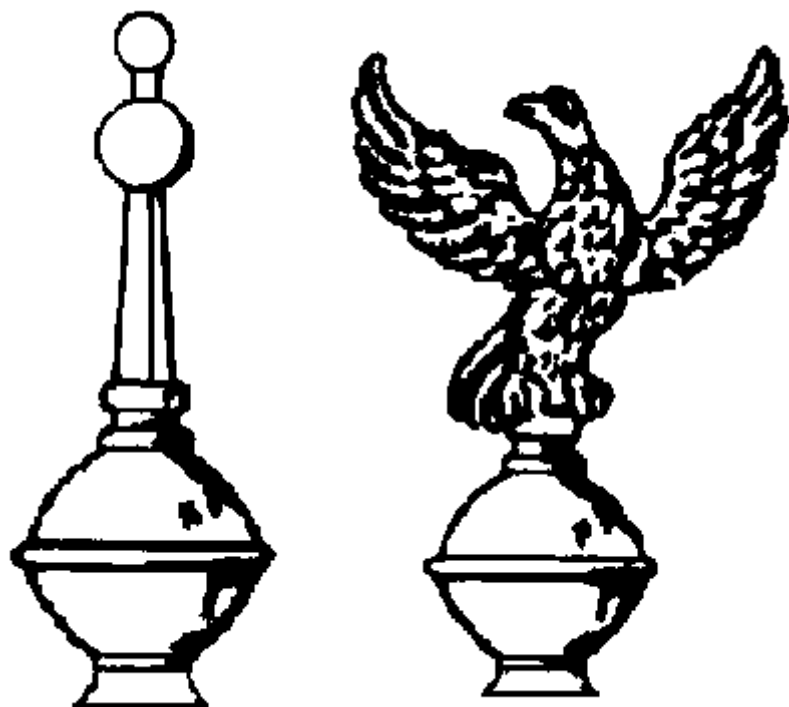


Figure 8. Ball and Eagle finials

flute: a semicircular vertical groove in a **pillar**.

foliated: carved with a leaf ornament.

helix: a spiral motif, especially on a [shaft](#) or [column](#).

moulding: a continuous ornamental band around a [shaft](#), [column](#), [capital](#) etc. There are many specially named types.

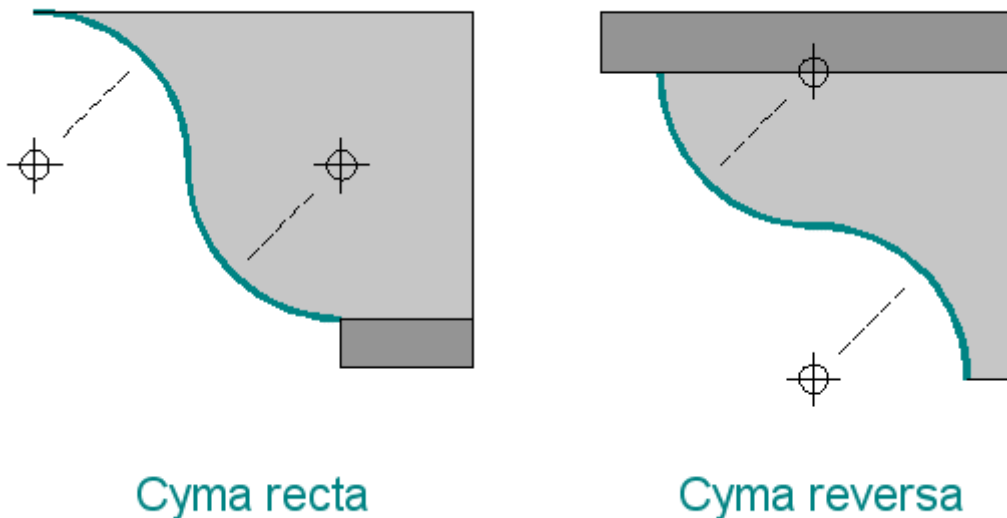


Figure 9. Ogee and reverse-ogee mouldings

nave: the body of a church, especially from the west door to the [chancel](#) and usually separated from the [aisles](#) by [pillars](#).

obelisk: a tall tapering shaft of stone, usually monolithic with a square or rectangular section ending with a pyramidal apex. Prominent in Ancient Egypt as a solar symbol, often at the entrance to tombs or as a cult object in shrines to the sun.

Order: in classical architecture, a term used to describe a column with its [base](#), [shaft](#), [capital](#) and entablature, designed in one of a number of accepted modes, for example Doric or Ionic. The component description of these Orders have been adapted for dialling purposes.

pedestal: the term adopted by diallists to describe the whole structure, usually of stone, used to support a dial (most usually horizontal). See **Figure 6**.

pediment: a low-pitched gable, sometimes seen over the top of vertical dials. It may be open at the apex, in which case it is termed a **broken-apex** ~ or sometimes just a **broken pediment**. Versions with curved segments are called **swan-neck** ~.

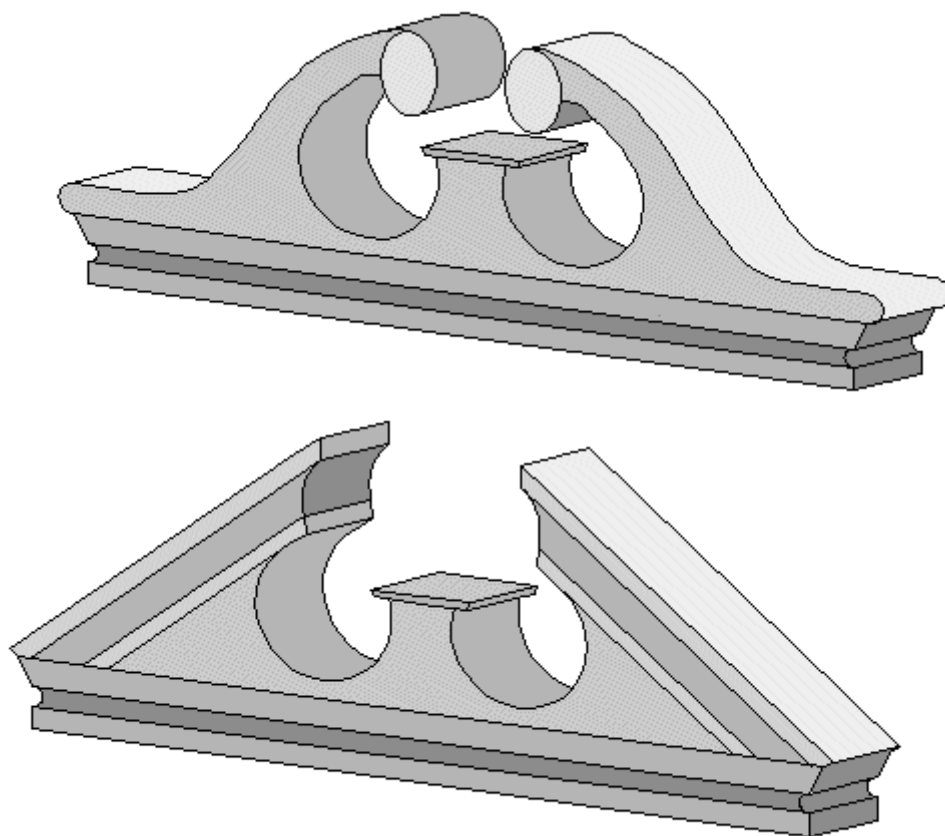


Figure 10. Swan and broken pediments

pillar: similar to the classical [column](#), but need not have the simple circular or square cross section.

plinth: the bottom part of a [pedestal](#), either in direct contact with the ground or with the general horizontal surface. It is often [chamfered](#) or with a [moulding](#) around it.

Priest's door: a door on the south-side of the [chancel](#) of a church, used by the clergy. Its surround is a common site for [mass dials](#).

shaft: the trunk of a classical [column](#), between the [base](#) and [capital](#). It may be used more loosely in dialling to describe the similar section of a [pedestal](#).

solarium: a sun terrace or loggia.

spandrel: an architectural term for the space between the shoulder of an arch and the surrounding rectangular brickwork. In dialling, the term can be used to describe the corner areas of a square [dial plate](#) with a circular [chapter ring](#).

transept: the transverse arms of a cross-shaped church, usually between the [nave](#) and the [chancel](#), but occasionally at the west end of the nave as well.

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APPENDIX X.

Astrolabe term

English	Latin	Arabic
alidade	ostensor	al-'Idada
astrolabe	astrolabium	asturlab
back	dorsum	zahr
cord		'ilaqa
front, face	facies	wajh
limb	limbus, margo	hajra, tawq, kuffa
mater	mater	umm
pin, axis	clavus, axis	qutb, watad, mihwar
plate	tympanum, tabula regionem	safiha
rete, net, spider	rete, aranea	'ankabût, shabaka
ring	armilla suspensoria	halka
ruler	index (or ostensor)	
shackle		'urwa, habs
swivel pin	armilla reflexea	
throne	armilla fixa	kursī
washer, ring	armilla	fals
wedge, horse, dog	equus, caballus, cuneus	faras

